THE

JOURNAL OF GAS LIGHTING,

WATER SUPPLY, & SANITARY IMPROVEMENT.

VOL. VI. No. 128—9th YEAR.] LONDON, SEPTEMBER 29, 1857. [Subscription per Ann. { 15s. in Advance / 18s. Credit.] Price 8d. Unstamped.

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"Gentlemen,—I have much pleasure in informing you that the Jury has awarded to your firm 'HONOURABLE MENTION FOR LAP-WELDED IRON TUBES.' You are at full liberty, if you deem it likely to promote your mercantile advantage, to affix to these articles, during the season 1854, a card whereon this Award is printed, and also your prices, with name of agent, &c.—I am, gentlemen, your obedient servant,
"JOHN H. BOHN, Secretary.
"Messrs. JAMES RUSSELL and SONS, Wednesbury, STAFFORDSHIRE."

CROSLEY & CO.,

GAS-METER MANUFACTURERS,

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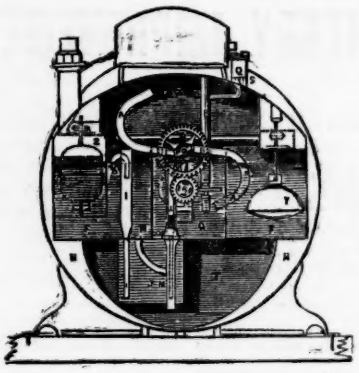

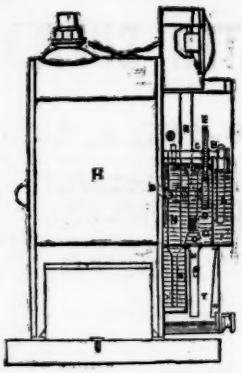

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Manufacturers of LOWE'S PATENT MOTIVE-POWER METER, for situations where there is an inadequacy of pressure to supply the special requirements of certain consumers in low grounds during the day or night.

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By Her Majesty's Royal Letters Patent.

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Also of every Description of Apparatus used in the Gas Factory, as well as in Gas Distribution.

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ESTABLISHED 1836.

PATRONIZED BY ALL THE GAS COMPANIES OF THE METROPOLIS, AS WELL AS MOST OF THE PROVINCIAL TOWNS.

J. MEACOCK'S PATENT DRY METER.

OLD VALVE OF THE ORDINARY DRY GAS-METER.

In the accompanying Diagrams of Meters will be seen J. MEACOCK'S patent method of securing the Leather Diaphragm of his IMPROVED PATENT DRY METER. Instead of using the soldering iron for the purpose, by which the Leather is more or less injured, it is held between two flat Metal Rings, and screwed up sound on to a frame to receive it, the outward rim of which and screw-heads are shown in the drawing.

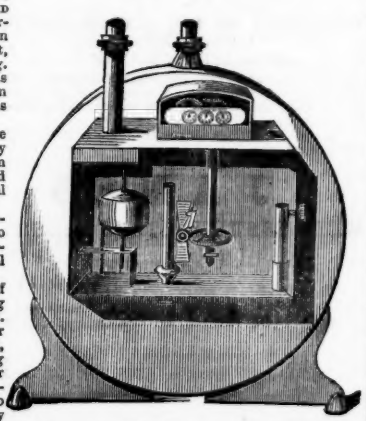
The Valve adopted in the above Patent Meter is also shown, as well as the ordinary Slide-Valve; the advantages of the former in not rising from its facing will be very apparent to the practical Gas Engineer, to whom it is of vital import.

J. MEACOCK begs leave most respectfully to submit to the notice of Gas Companies his PATENT DRY GAS-METER, trusting thereby to receive the same encouragement that has been so kindly awarded him in respect of his Improved Water-Meter, which has been patronized by all the Metropolitan Companies, as well as most of the Provincial Gas-works.

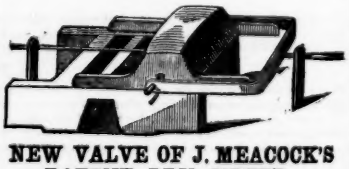
The public having been induced to desire Dry Gas-Meters in preference to Wet, and many Gas Companies being willing to yield to their wishes, J. M. has been induced to apply himself to the production of a Dry Meter, for which he has obtained Her Majesty's Royal Letters Patent.

Very frequently in fitting up the ordinary Dry Meter, the leather of the diaphragm is destroyed during the process of soldering, by coming in contact with the hot soldering iron. In his present process, J. M. has done away with its use, no solder being necessary, the leather being secured by two flat metal rings, between which it is screwed, riveted, or overlaid; the perishing effect of hot tools to leather being avoided, its durability must be longer; also, by this means, its repair when needful is most simple, as a new leather diaphragm can be applied by merely unscrewing the old one from the rim or frame to which it had previously been screwed up sound. In the ordinary Dry Meter frequent variations of registry have been detectable from defective valves, which tilt or rise from their facings: the slide-valve of this Patent Dry Meter will not allow any carbonaceous matter common to coal gas to tilt or lift the slide from its facings, and hence no variation. The heavy wear and tear to which the Meters of Gas Companies are subject, have at all times made it desirable to have them of the best materials and workmanship. J. M. begs leave to assure those who may honour him with their commands, that nothing but the stoutest materials for cases, the hardest gas-resisting metals, and best foreign leather for the interiors, will be used, and none but first-class workmen employed in their construction (the properties which his Improved Water-Meter is well known to possess, and which has obtained him that extensive patronage), will be strictly carried out in his PATENT DRY METER.

In respect of any orders with which he may be honoured, he is willing to give a guarantee to keep the same in repair, *free of all charge*, for three years, and allow the customary discount off the original list price.



J. MEACOCK'S IMPROVED WET METER.



NEW VALVE OF J. MEACOCK'S PATENT DRY METER.

Wet Gas-Meters Repaired and Reconstructed with J. Meacock's Modern Improvements.

METERS SENT ON APPROVAL.

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NOTICES.

The subscription is 15s. per annum, if paid in advance, or 18s. on credit, payable in two sums of 9s. each, in July and January of each year, by Post-Office order, to Thomas G. Barlow, at the Charing-Cross Money-Order Office.

The next number will be published on Tuesday, Oct. 13, and the subsequent numbers on each successive alternate Tuesday.

Stamped copies, when forwarded by post, must be folded so as to expose the stamp; they are otherwise liable to the full postage charge for letters.

This JOURNAL has been duly registered at the General Post Office for transmission abroad.

All Communications to be addressed to the Editor, No. 42, Parliament Street, Westminster; and orders for Advertisements to Mr. W. B. King, the Publisher, No. 11, Bolt Court, Fleet Street.

THE JOURNAL OF GAS LIGHTING, WATER SUPPLY, & SANITARY IMPROVEMENT.

TUESDAY, SEPTEMBER 29, 1857.

NOTES UPON PASSING EVENTS.

TOM MOORE regretted, in his Loves of the Angels, that

> "Here
> Nothing bright is seen but it hath pain and peril near,
> Where right and wrong so closely resemble, that"—

in sober prose—'tis hard to say how the limits of truth and of falsehood are to be discerned. Where, indeed, does the good of scientific associations, of expositions, or of congresses cease? and where do those various institutions degenerate into mere organs of quackery and humbug? No doubt bodies like the Royal Society and the *Académie des Sciences* have done great service to humanity in their day; but it is not less true that they have often been made the instruments for building up scientific reputations of a very questionable character; and, to cite contemporary illustrations, the great *Académie des Sciences* itself has sorely diminished its *prestige* by the importance it has conferred upon Prince Napoleon's ornithological fancies, or upon M. Ville's questionable chemistry. No doubt, also, the first expositions in France and in England roused attention to the state of art and manufactures in those countries; but they have sunk irretrievably into displays of catch-penny wares, and have become almost literally great advertising shops. And so, likewise, the system of congresses for scientific purposes seems to be passing from the sincere and useful phase of its existence into that of furnishing artful schemers with the opportunity for promulgating, from a certain vantage ground, the doctrines upon which they base their plans for securing pay and position for themselves. The whole affair of these congresses fortunately, however, seems likely soon to degenerate into a palpable farce, and thus to succumb under the contempt of the thinking world. In Vienna, they say, the dancing-masters have met in congress for the purpose of guiding public opinion in the advancement of the Terpsichorean art; nor can we, for the life of us, see that these saltatory meetings are more absurd in their way than the one to be held shortly at Birmingham. Public opinion, in the soberer matters intended to be discussed at the latter town, will eventually, we are convinced, exercise itself as freely as it will do in the matter of new dances, polkas, shuffles, or what not; but the absurdity of both assemblages lies in the supposition that mankind want such self-constituted guidance either in social science or in dancing. The mischief, however, of these institutions is that they impose upon the weak and the unreasoning, with all the weight of authority and numbers; for men are too much like Panurge's sheep, and they blindly follow one another over the ship's side into any error to which their bell weather may lead them. Modest men—those, in fact, who can enlighten mankind—are rarely those who are able to shine in public meetings. The great elements of success in such scenes are a perfect contempt for the audience and a reckless self-confidence, which can prevent a man from being staggered by any new arguments urged against his preconceived opinions. These mental qualifications, a glib tongue, and a loud voice, are all that are required and nearly all that are usually possessed by the leaders of congresses or of scientific associations; and most earnestly do we beg the public to examine the doctrines thus propounded by the light of its own judgment, and to resist the attempts which are being made by the social science, or the Terpsichorean, self-constituted guides to promulgate the doctrines most advantageous to themselves.

We have, moreover, lately witnessed such fearful illustrations of the mischief the school of social science guides has inflicted upon our community, as ought to be sufficient to compel any rational people to pause long and to deliberate seriously before it yields itself further to their experiments. Look, for instance, at the law of limited liability in partnerships. Is it possible for more evil to have arisen from any one measure than has already been caused by this bill, which Lord Palmerston, with his usual good taste, forced upon the Legislature in the teeth of all remonstrance as to its incomplete and undigested nature? We have lately seen the Surrey Gardens Company, the Hull Flax and Cotton Mill Company, the London and Manchester Warehouse Company, the West of Ireland Fishing and Fish Manure Company, and the North of Europe Steam Navigation Company, present to their unfortunate creditors and shareholders disastrous statements of loss and ruin, which certainly never could have been incurred so rapidly if the men who pretended to draw up the Act of Parliament they (the companies) had adopted had possessed the slightest knowledge of law or of business. In this JOURNAL, we again and again called attention to the ridiculous blunder made by the awkward official imitators of the French law of partnership *en commandite*, which consisted in the omission of all the precautions and penalties attaching to any interference with the management of the concerns of the partnership. And now, again, with the results of the operation of the Act before our eyes, we repeat that it is neither more nor less than a measure for the nominal protection of sleeping partners, and for securing an efficient immunity for incapable or dishonest directors. The Act is a disgrace to the statute book, and Mr. Sampson, the writer of the money articles of the *Times*, knows that it is so, though the connexion of his former colleague, Mr. Lowe, with the Government makes him anxious to gloss over the defects of a measure his colleague was instrumental in passing.

Then, again, look at the results of the meddling with the local affairs of our corporations and parishes by the new guides of the Benthamite school; for it is to be observed that the spirit of that great centralizer and formalist really pervades the whole clan of the reformers of social science. Take the Public Health Act for one instance. The sheriff's officers have actually been in possession of the properties of the Boards of Worksop, Rotherham, Wolverhampton and Dartford—perhaps elsewhere, for aught that we know. The works sanctioned by, and executed under the inspection of, the General Board of Health at Dover, Sandgate, Croydon, Dartford, Luton, Epsom, Uxbridge, Stratford-upon-Avon, Southampton, Salisbury, Rugby, Sheffield, Rotherham, and many other places whose names do not immediately occur to us, have either proved signal failures, or have entailed law-suits and burthens upon the unfortunate towns of the heaviest and most distressing description. We do not believe that such things ever occurred before during

the existence of our ancient local liberties; at any rate, it was the duty of the board which constituted itself the guardian of the public purse against local jobbery and professional incompetence to have prevented the gross system of centralized jobbery Sir B. Hall could once so indignantly stigmatize, and against the professional blunders of its own servants. Then take the Metropolis Management Act as another instance of the results of modern legislation! Not only are the works for the great intercepting sewers brought to a dead lock by the impertinent interference of that "tinkling cymbal," Big Ben, but even the security of a large and important district like the Isle of Dogs is left at the discretion of any unprincipled builder or landowner, or to the tender mercies of those cadis, the police magistrates, from the carelessness or ignorance of the man who drew the Act. Surely, the parties who could produce such a very unsatisfactory state of public affairs are but poor guides to public opinion in matters requiring deep research, and profound studies of legal, technical, and practical details! and men of the present or past General Board of Health calibre, may well be advised themselves to go to school before they attempt "to guide public opinion in matters connected with social science."

The story of the town of Dartford, to which we have alluded, is a very sad one, and it is one which the members for the county of Kent would be bound to bring before Parliament, if our representative system were anything more than a sham. The General Board of Health, it appears from a petition presented to the House of Commons in 1855, sent one of their superintending inspectors to examine and report upon the sanitary state of the district in 1849. His report stated that for a comparatively small sum all the evils he then pointed out could be remedied, and that a perfect system of sewerage and water supply could be carried into effect. The Local Board then employed the very same inspector to execute the scheme he had recommended; but, after expending every farthing it was empowered to raise, it found itself with an imperfect set of water and sewerage works, which had already cost far more than the entire original estimate, and which could not be completed according to the plans without a very serious additional outlay; whilst the numerous accidents which had already happened to the well and to the outfall sewer rendered it more than probable that a considerable portion of the works would have to be remodelled. This was the state of things in 1855; since then it has only been diversified by law-suits, and finally by the intervention of the sheriff's officers, who have taken, or are about to take, possession of all the accessible property of the Local Board. It is said that this property is far from being sufficient to pay the legal expenses recently incurred; so that the ratepayers of Dartford are now in the delightful position of having to pay a debt of at least £12,000, from which they never by any possible chance can derive any benefit. And this, be it observed, simply because they allowed themselves to be guided by the very men who figure the most prominently in the committee of the fourth section of the Birmingham congress!

As to the London intercepting sewers, it appears that the autocrat of Her Majesty's works and buildings has decidedly rejected the B* plan of the Metropolitan Board; and has referred that namby-pamby body to the report of Messrs. Simpson, Blackwell, and Galton for his views upon the subject. What next? It is absurd to suppose that the board which has hitherto truckled to the former advocate of local self-government should now assume any independent position; for the few bold, honest members are sure to be outvoted by the times'-servers who have thus far played the game of Sir B. Hall. The only hope that we can see is to be found in the possibility of the various local boards insisting upon the rejection of the monstrous project of the referees, and upon the deliberate investigation of the whole matter before a well-selected and *an impartial* committee of the House of Commons. It is a farce to suppose that this business ought to be allowed thus to be bandied about between a properly-constituted local authority and an impertinent, upstart, engineering amateur, like the present First Commissioner of Works; and the sooner the existing anomalous state of affairs is knocked on the head the better. Either the inhabitants of London are able to select proper governors for themselves, or they are not. If the former be the case, the local authorities alone ought to have a voice in the works required for the benefit of their constituents: if it be not, why retain the farce of the Metropolitan Board of Works at all?

The "Appendix" to the report of the referees in this sewerage question has at last made its appearance in the shape of a huge and costly blue-book. It is indeed so long, so rambling, and so ill-arranged, that we confess that we have not yet been able to master its contents; and we do not propose, therefore, at present to dwell upon it, further than to say that it contains several very curious and important papers upon questions of hydraulic engineering to which we will certainly return.

In the meantime, we cannot refrain from recording our protest against one of the principles propounded by Captain Galton, R.E. (one of Sir B. Hall's referees), in a report he has lately issued with reference to the particular branch of public administration for which he appears to have an equal innate capacity as he has for that of metropolitan sewerage, viz., the railway department of the Board of Trade. In this report, after alluding to the Northern Railway frauds, Captain Galton repeats the parrot cry of the day, that no security for public companies can exist without an independent, *i.e.* a Government, audit. Now we would, firstly, observe, that if an independent audit mean anything, it must mean the abdication of all private control over the operations of the companies submitted to it; for he who holds the keys of the money chest, with power to bind or to loose, must eventually become the acting director of every concern in which he intervenes. A Government audit, then, means a Government control of the working of our railways; and we suspect that the notorious incapacity of all our administrative departments—the strange fatality which throws them all into the hands of quacks or of incapable Barnacles—would hardly be likely to induce the public to entertain such a notion favourably. But, secondly, we would observe that the disgraceful jugglery with respect to the public accounts recently exposed by the squabble between Lord Monteagle and Sir C. Trevyllian is very far from being of a nature to inspire confidence in the sincerity or the efficiency of a Government audit; nor can the extraordinary proceedings with respect to the Appropriation Bill of this year, to which we have already called attention, add much to the character or influence of those whom it is now proposed to entrust with the superintendence of the funds of private companies. They, too, who recollect how easily the Government auditors were deceived in the case of the Exchequer Bill frauds, which furnished funds for the Boulogne expedition of eagle and sausage shop notoriety, are not likely to attach much value to a control so easily defeated. The fact is, that the shareholders of every concern ought to protect themselves: and that it is but trusting to a broken reed to cast upon the careless, indifferent servants of the State duties and responsibilities which are really incumbent upon individuals in their private capacity. This last, however, appears to be the direction towards which our social science reformers seek to guide public opinion. They desire to substitute the action of Governmental boards for that of private enterprise; centralization and red tape for local self-government; bureaucracy and the police for individual liberty. Alas! we have made, as a nation, great progress in this direction since the days when P. L. Courrier could have said "that the English ministry was as bad as the French; that it corrupted the nation in a similar manner; but that they (the English) had no police"—an institution he justly stigmatized as "the most powerful of all the methods ever invented for rendering a nation vile and cowardly." We have begun to tolerate the intervention of the police in our factories and in our common lodging-houses; nor can we say where they will stop, if such misguided philanthropists as Mr. Cowper should have their way. But if we allow the Government to extend its mischievous intervention in the affairs of private companies, we may at once be sure that the knell of English prosperity will soon be rung. Our national greatness has hitherto depended on our retaining a weak Government over a strong nation; if we reverse these conditions, as continental nations have done, we shall infallibly subside, as their populations are rapidly doing, into an equality of misery. Bad as the conduct of railway and steamboat company directors may have been, there is no security that Government officials would be either better or more honest; and, therefore, most earnestly do we urge the shareholders, in railways especially, to resist the attempts which will be made to foist upon them, in the course of a few years, a so-called "independent audit." Their interest being the largest, will be the first to be sacrificed.

There are, it appears, one or more cases of appeals from

parochial rating by gas, water, or railway companies about to be submitted to the superior courts of law. How long will the companies tolerate the disgraceful state of things with which these proceedings are connected? and how long will they continue their isolated resistance to the system of plunder to which they are now exposed? A very small combination would suffice to compel the Government to name a select committee to examine the whole matter. At present, nobody seems to have any fixed ideas on the subject; whilst, practically, the companies are robbed on every side. And they will continue to be thus robbed until they act in concert, and until they show a disposition to unite in defence of their just rights. It is idle to contend in detail with the assessments of particular parishes, so long as the principles of the law of assessment are left in their present vague and unsatisfactory state; and companies may depend upon it that nothing will be done in the matter until the shareholders compel their directors to act vigorously upon the Legislature. At present, we fear it is but too true that they get plenty of law, but no justice.

The great experiment of sinking another artesian well at Passy, in the tertiary basin of Paris, seems to be attended with unexpected difficulties. It was calculated originally that the water would be met with at a distance of about 550 mètres (1804 feet) from the surface, and the well at Grenelle is actually only about 1802 feet deep. But the boring at Passy is now said to have been suspended, on account of some accident to the tools, after having attained a depth of not less than 680 mètres, or 2230 feet. We suspect that there is some error in our information; but if it be correct, the temperature of the water obtained from such a depth will be very objectionable for the purposes this source is intended to supply. M. Walferdin stated some years since that the constant temperature of the ground at Paris, at a depth of 94 feet from the surface, was 53·06 F., and that the temperature thence increased regularly at the rate of 1·7 for every 100 feet of additional depth. At this rate, the temperature of the ground at the bottom of the Passy well would be about 89·37° F., and the water would rise to the surface at nearly the same degree of heat: the water at Grenelle actually rises at 82°. The decomposing action of tepid water of this description strikes us as being a serious objection to its use in an ornamental basin such as that of the Bois de Boulogne. The communication of M. Dupuit to the *Académie des Sciences*, which we have translated in a subsequent part of this JOURNAL, adds to the interest with which this work at Passy is regarded by engineers and geologists.

Circular to Gas Companies.

IT is an undeniable fact that the principal source of complaint against gas-works situated in populous neighbourhoods lies in the smoke which escapes from the retort-house during the operation of charging and discharging the retorts. This inconvenience was pointed out by the committee of medical officers who recently inspected the Metropolitan Gas-Works, and numerous suggestions have been thrown out with the view of diminishing the nuisance, some of which have been tried with but partial success. The peculiar construction of the Western Gas-Works at Kensall Green has, however, permitted the application of a comprehensive system of ventilation, which promises such complete success as to justify our laying the details before our readers, accompanied by the illustrations, which will be found in another page of the present number.

The retort-house is a polygon of 12 sides, about 150 feet diameter, with a concentric polygonical building, also of 12 sides, 50 feet diameter, in which the purifiers were at first fixed. It was originally intended to place the retorts with their backs against the outer wall, and provision was made for the reception of 228 D-shaped iron-retorts 21 inches wide by 10 inches high, and 6 feet 4 inches long. Taking the gas-producing power at 3000 feet per retort per diem, the total producing power of the house when filled would have been 684,000 feet per diem; but when two-thirds of the retorts were in action, the temperature of the house became so fearfully oppressive as to affect the health of the stokers, and render imperative a total change in the system. These changes have been carried out by instalments, under the direction of Mr. Alexander Wright, the company's present engineer, whose experienced eye did not fail to perceive the facilities which the peculiar plan of the buildings offered for the adoption of an arrangement which, while it more than doubled the producing power of the retort-house, would ensure its complete ventilation. These objects have been accomplished, first, by the removal of the purifiers from the centre building to make room for a new chimney, which should serve at the same time to carry off the products of combustion and to renew the air in the retort-house; and, next, by the substitution of six benches of retorts, radiating from the centre, for the ring of retorts originally erected round the external wall. Each bench is designed to contain five beds, and each bed six long-range round clay retorts, 16 inches diameter and 20 feet long; the total gas-producing power of the house, when filled with retorts, being 1,620,000 cubic feet per diem. The chimney is 130 feet 6 inches high, above the ground-line. The inner shaft, which carries off the products of combustion, is 6 feet 6 inches internal diameter throughout, and 81 feet high, above the level at which the hot-air flues enter. It is built entirely of 9-inch fire-brick, moulded to the circle, and worked three courses headers and three courses stretchers. The exterior or ventilating shaft is 12 feet internal diameter throughout, and 97 feet high above the level at which the cold-air flues enter. The brick-work is 3 feet thick at the base of the column, tapering externally to 18 inches at the top. The cap is of light cast-iron, filled in with brick-work, &c. A spiral staircase, of 72 treads, is constructed in the space between the two shafts; the treads are of cast-iron, built into the brickwork of the external shaft (and barely touching the interior one), connected together by a $\frac{3}{8}$ copper wire rope, communicating with a lightning conductor formed by a similar rope, five-eighths in diameter, provided with two points 4 feet high, above the top of the chimney, and opposite to each other. The vacant space in the centre building serves as a general receptacle for coals, from whence it is taken direct to the retorts; and as there is a railway communication between this distributing-store and the canal, the labour of delivering the coal at the retort mouth is much below the ordinary rate.

The principal novelty in this chimney consists in the exterior, a ventilating shaft being carried some 25 feet above the top of the interior or smoke-shaft; by this means, every degree of heat by which the products of combustion exceed the temperature of the external column of air is employed in increasing the current in the ventilating shaft. In the great chimney at the Hamburg Gas-Works, the two shafts discharge at the same level, and hence the motive power is there confined to the difference between the density of the column of air in the ventilating shaft due to the increase of temperature acquired by contact with the warm brickwork of the smoke-shaft, and the density of the external air; the motive power capable of being obtained from the heat of the products of combustion at the point where they escape, being completely lost. Experience alone can determine what the effect will be of the various contrivances adopted at the Western Works for increasing the efficiency of the ventilating shaft; but, from experiments already made, it is believed that a vacuum equal to a column of water half an inch high will be produced, when the whole of the retorts are in action. This would renew the air in the house once in three minutes; and, as the roof is air-tight, and the fresh air sweeps past the front of the retort-beds from the apertures in the external walls, the smoke will be carried direct into the chimney, and the stokers will perform their labours in a comparatively cool atmosphere. We shall have occasion again to refer to this subject when the actual results can be ascertained; and, in the meantime, we give the following further details, as points for comparison with other similar structures: —

Number of furnaces discharging into the smoke-shaft	60	
Aggregate area of the surface of the furnaces	100	square feet.
Aggregate area of the apertures into the smoke-shaft	81	do.
Area of the smoke-shaft	33·1	do.
Height of do. above the furnace-bars	98	feet.
Aggregate area of the cold air-flue apertures into the ventilating shaft	42·4	square feet.
Area of the ventilating shaft	62·8	do.

With reference to the Kimeridge shale, and the attempt to find a market for it under the title of "South Boghead Coal," as mentioned in our last, we are informed that all intention of introducing it as a gas-making material has been abandoned by the lessee of the property, and that he has entered into

an arrangement with influential parties in France for working the mineral, to be used instead of the true Boghead in the manufacture of mineral oils, an unlimited demand for which exists in France. We insert elsewhere the able report of Dr. Hofmann on this material, from which it appears that it differs considerably in quality, three samples having yielded, on analysis, the following results:—

	No. 1.	No. 2.	No. 3.
Volatile matter	19·51	52·8	73·3
Mineral matter	80·49	47·2	26·7
Total	100·00	100·0	100·0

Sample No. 1 is evidently worthless, No. 2 might be worked on the spot, and No. 3 might be exported. The parties who are understood to have embarked in the speculation have had great experience in the manufacture of oils from coal tar, and assert that they have succeeded in making a marketable article from the tar of the Kimeridge shale. If Dr. Fitton's paper "On the Strata between the Chalk and the Oxford Oolite," read before the Geological Society in 1827, is to be relied upon, a similar formation is fully developed in the "Lower Boulonnais," and on the coast of Yorkshire near Scarborough, and it is not improbable that it may be found throughout the outcrop of the upper oolitic series between Calne and Aylesbury.

Mr. R. Laming has favoured us with a letter upon the subject of lightning conductors, by way of commentary upon the article upon the subject inserted in a late number, and we beg to call the attention of our readers to this very able communication. The importance of the investigation cannot be exaggerated; and, whilst thanking Mr. Laming sincerely for his letter, we invite our other kind friends to assist us in acquiring and diffusing information upon the subject, to which we may hereafter return.

Communicated Articles.

ANALYSIS OF A MEMOIRE UPON THE MOVEMENT OF WATER THROUH PERMEABLE SOILS.

By M. Dupuit.

(Translated from the *Comptes Rendus de l'Académie des Sciences* for the 20th July, 1857.)

The movement of water through permeable soils has hitherto been studied to a very slight extent, either in a theoretical or a practical point of view. The phenomena which it presents are, however, of great interest; for the underground waters which filter through the soil play an important part both in agriculture and in industrial operations, whether it be desired to use them, or merely to remove them. Natural springs, ordinary wells, artesian wells, dead or absorbing wells, stone drains, natural or artificial filters, drainage, coffer-dams, stopping out water, drying a foundation, and many other hydraulic works, may be facilitated or improved by the application of the theory which the following *Mémoire* proposes to explain.

At the first glance, it would seem that the movement of the water which divides itself amongst the numerous pores of a permeable body would be more complicated than that of a large section, which would only meet with the resistance due to friction, and to the adherence of the molecules. This is not, however, the case; when the question is closely examined, it will be found that this movement is only a particular case of the ordinary movement in tubes of very small diameter; and that for this very reason, as it is only a question of small velocities, and of very small sections, the special formulæ of these movements are debarrassed of certain terms which complicate those relative to large sections and great velocities.

In the ordinary movement of water, the relation between the inclination of the surface and the mean velocity contains, in addition to the two first powers of that velocity, the ratio of the section to the wet contour. In the movement through a permeable mass, the term relating to the square of the velocity may be neglected, and the ratio between the section and the perimeter disappears in the term relating to the first power of the velocity; so that the formula of the uniform movement of ordinary watercourses,

$$i = \frac{\chi}{\omega}(\alpha v + \beta v^2),$$

becomes in permeable soils

$$i = \mu v;$$

these theoretical inductions have been fully confirmed by the experiments upon filtration recorded in the recent work of M. Darcy upon the fountains of Dijon.

The preceding formula applies to the variable, as well as to the uniform movement, inasmuch as the term relating to the variation of the velocity may always be neglected. There is, then, only one formula for the movement of water through permeable strata; and it is to be remarked that it is more exact than that of the ordinary movement, insomuch as the latter attributes to all the fluid threads a velocity equal to the mean velocity, although this is not correct in large sections in which they assume velocities sensibly different.

Starting from the formula $i = \mu v$, I establish in detail (in the paper from which this notice is condensed) the equations of the surface of the water when it filters freely through a permeable soil, in a channel of variable inclinations and widths; and I compare them with those obtained for ordinary watercourses in my work, "*Etudes sur le Mouvement des Eaux Courantes*," published in 1848. The equations at which I arrive prove that these surfaces, independent of the co-efficient of permeability, confound themselves with those of superficial watercourses, when the backwaters are not very considerable, only they correspond to heights of the uniform regime, which are three times greater; it follows from this, that when, by means of a dam, a contraction, or an enlargement, the water surface of the water-bearing strata is altered, this alteration extends its effects much farther than it would do in the case of a superficial watercourse. Proceeding, then, to examine the case in which the water surface is forced between two impermeable strata, I determine its pressure upon every point, or, in other words, the height to which the water would rise in a vertical tube of an indefinite length. This particular movement, which is in all respects the same as that of water in pipes, gives rise to formulæ analogous to those published in my work, "*Traité de la Distribution des Eaux*," published in 1854. The *Mémoire* terminates with the application of these general formulæ to the movement of subterranean waters, and specially to the determination of the quantity of water which can be collected from water-bearing strata with an open or free surface by means of wells, or from subterranean water-bearing strata by means of artesian wells.

I show (in this part) that, by establishing a system of drainage in a water-bearing stratum sensibly horizontal, the new surface of the water does not depend upon the thickness of the stratum, nor of the permeability of the ground; that those quantities* only affect the yield, which is proportional to the quantity† by which the water in the well has been lowered; as to the diameter, the perimeter, the surface, and the depth of the well, their influence almost disappears before that exerted by the lowering of the water-surface. The comparison between the expression of the yield of a well and that of a mètre lineal of longitudinal gallery driven at the same depth, demonstrates the enormous advantage of wells over galleries, especially when the reservoir which feeds the filtering mass is far removed from the centre of the well. It is a peculiarity which may be usefully applied, either for the establishment of natural filters, or for vertical drainage, or in the pumping required for hydraulic works.

By means of a change in a sign, the formulæ relating to ordinary wells may be applied to absorbing wells, which, under these circumstances, do not require any special theory. Those which affect artesian wells, themselves more simple than the formulæ for ordinary wells, exhibit properties in all respects analogous.

With respect to the diameter of such artesian wells, or to that of the ascensional tube, I show that its influence is very insignificant, as in the case of ordinary wells. This property I have endeavoured to prove both theoretically and experimentally, on account of its practical importance. The diameter of a boring should, then, be decided simply by the considerations connected with rendering the labour as cheap as possible. I determine, moreover, the character by which it would be easy to ascertain the insufficiency of this dimension in proportion to the delivery; and I cite, as a proof of my theory, the works executed for the consolidation of the well of Grenelle during the time that I was charged with the municipal service of Paris. The yield of this well having considerably diminished in consequence of the deviation of the lower part of the tubing, we were obliged to place in the interior of the latter a smaller tube; and, in order to prevent a recurrence of this accident, we thought it advisable to strengthen the lower part of this tube by a quadrangular rod, which closes its horizontal end, and fixes into the ground: so that at present the water only enters through some holes pierced in the vertical sides, and can only move in the small space comprised between the square and the circumscribed circle. These works, executed under my orders by M. Mulot, have not sensibly diminished the yield of the well. In fact, that which really limits the yield is the enormous friction the water experiences in the filtering medium, and not that of the ascensional tube. No advantage will therefore be gained at the well of Passy, in consequence of the large diameter given to it. If an increased supply be obtained from the same source, it will be owing to other local circumstances.

I then examine the reciprocal influence of neighbouring wells. I show that, by multiplying them indefinitely upon a vertical section of the stratum, only a fraction of its total product can be obtained, depending upon the ratio between the load on the orifice of the tube and the height of the line of pressure upon the escape-outlet. At Paris, for instance, supposing, as we are justified in doing, that the underground stream passes ultimately into the sea, it would be impossible to cause to rise, to the height of the ascensional tube, more than $\frac{6}{10}\frac{7}{5}$ths of the whole yield of the stream; so that, by multiplying wells, the quantity of water is not necessarily

* *Sic*; does not the author mean conditions?

† *Sic*; *query* extent?

multiplied, but, on the contrary, this is a mode of reaching a limit which at times is not very remote. Thus, at Tours, the yield of every well has diminished in proportion as new borings have been made.

It follows from these considerations, that the spacing of artesian wells must be calculated according to certain local circumstances, and that this system, which may be adapted to scattered populations, becomes insufficient for dense agglomerations of inhabitants, who require large quantities of water for small surfaces. The quantity of water which may be thus obtained is, moreover, very variable, according to the thickness and to the permeability of the water-bearing strata. Now, the artesian stratum of the well of Grenelle is, unfortunately, but small, if compared with numerous other strata which feed well-known wells; the quantity of water obtained (about 12½ litres per second) is only due to the pressure existing upon the orifice, which is equal to 57 mètres—about 188 feet 7 inches. It would follow from these assumptions that borings near Paris must extend their action to a great distance, and that they ought to be placed at considerable intervals. In this respect the experiment of Passy may furnish useful information, for it is not impossible that this boring may affect the yield of the well of Grenelle.

I propose hereafter to continue the application of the laws of the movement of water through permeable strata to numerous questions of the greatest interest to science and industry. They offer a new field for the investigations of applied mechanics. My principal object in this *Mémoire* is to call attention to their nature and practical importance.

REPORT ON THE BITUMINOUS SHALE OF KIMERIDGE, DORSETSHIRE.

By Dr. A. W. Hoffman, F.R.S., &c., &c., Royal College of Chemistry.

The material submitted to examination has the appearance of a true slate, and possesses in a high degree the characteristic cleavage which distinguishes this class of compound rocks.

The colour varies somewhat between a greenish and brownish grey slate colour. It is rather soft, so that it can be readily cut with a knife.

Numerous species of petrifaction, almost entirely belonging to the animal kingdom, abound in this shale. They generally consist of carbonate of lime, and partly iron pyrites.

When heated, this mineral first gives off copious fumes of an unpleasant odour, somewhat resembling that of petroleum; when ignited, it continues to burn by itself, with a dull smoky flame, and leaves, when freely exposed to the atmosphere, a reddish ash, generally retaining the shape of the original fragment.

This property is more or less exhibited by all the pieces of the large amount of material transmitted for analysis.

Nevertheless, upon a closer examination, it is found that the several specimens vary considerably in their nature, which arises probably from their belonging to different strata. Some of the specimens do not possess the delicate cleavage which is observed in others; in many instances the cleavage is perceptible only in large masses, the slaty nature having almost entirely disappeared, so that the shale greatly resembles the well known Boghead cannel coal.

As might be naturally expected, this variation in the external appearance is closely connected with the composition of the mineral. Analysis has shown that it arises chiefly from a difference in the relative proportion of the mineral and organic constituents. This may be readily seen by a glance at the results obtained in the analysis of the following three specimens:—

Specimen I.

Colour—Greyish green.
Cleavage—Delicate.
Ash—Very dense and hard, and retaining the shape of the original fragment.

Amount of volatile matter	19·51
„ *mineral matter*	80·49
	100·000

The numbers given are the average of three well-concordant analyses.

Specimen II.

Abundance of petrifactions, consisting chiefly of iron pyrites.
Colour and cleavage—Similar to those of Specimen I.
Ash—Less dense than that of Specimen I.

Amount of volatile matter	52·8
„ *mineral matter*	47·2
	100·0

Specimen III.

Colour—Rather brown.
Cleavage—Less distinct than that of Specimens I. and II.
Fracture—Conchoidal.
Ash—Loose, and presenting no longer the shape of the original shale.

Amount of volatile matter	73·3
„ *mineral matter*	26·7
	100·0

The above specimens, which were selected with care and discrimination, may be considered as fairly representing the average range of variation over which the composition of this material extends. Specimen I. is probably the poorest, specimen III. the richest variety.

In order to ascertain how far this shale might be applied to the purposes of the arts and manufactures, a series of experiments were carried out on as large a scale as the appliances of the laboratory would permit. In performing the experiments, care was taken to imitate, as far as possible, the circumstances under which the operations would be conducted for the purposes of practice.

Examination of the Products furnished by the Distillation of the Dorsetshire Shale.

I.—Volatile Products.

A.—Gas.

This last remark applies particularly to the investigation of the gaseous product obtained.

Experiments made on a very small scale furnish almost invariably a more favourable result than can be obtained on the large scale, when it becomes impossible to attend with the same care to all the details of the operation.

In order to avoid this error as far as possible, I have examined the gases evolved from the Dorsetshire shale, in the laboratory of my friend, Mr. Evans, at the Chartered Gas Company's works, Westminster, who kindly placed at my disposal all the resources of his establishment. Mr. Evans's experimental apparatus for the production, the purification, and collection of the gas, his dispositions for the analysis, and, lastly, his photometrical arrangements, are based upon a thorough knowledge of the scientific principles involved in the question, and have materially assisted me in obtaining the following data, which may be considered as fairly representing the results obtainable in practice.

It deserves to be noticed, that the following numbers are almost invariably the avarages of three, and often of more, well-concordant experiments.

Per centage of coke furnished by the shale, when heated in an experimental gas retort	36·50
Amount of gas, freed from carbonic acid and sulphuretted hydrogen, by passing through an ordinary lime purifier, furnished by a ton of shale, when submitted to the distillation in experimental gas retort, at a red heat, cubic feet	11,300

Composition of the Purified Gas.

Olefiant gas and congeners	10
Light carburetted hydrogen and hydrogen	79
Carbonic oxide	11
	100
The illuminating power of the gas, which, burning from an argand burner, consumed 5 cubic feet per hour, sperm candles	20

Composition of the Crude Gas.

Olefiant gas and congeners	8·8
Light carburetted hydrogen and hydrogen	69·3
Carbonic oxide	9·7
Carbonic acid	5·2
Sulphuretted hydrogen	7·0
	100·0

B.—Liquid and Solid Products.

The distillation of the shale was conducted in a large iron vessel, holding about ten pounds of the mineral, into the well-fitting lid of which an iron tube was fixed. This tube was attached to a powerful condenser, the retainer of which was connected with a series of Woolfe's bottles, through which the gaseous products of the distillation had to pass, so that any liquid or solid matter they might contain in suspension could be extracted.

The iron still was placed into a furnace specially constructed for the purpose, which permitted to give a gradually increasing heat.

When the temperature had risen considerably above the melting point of lead, aqueous vapours were first given off, which were followed by a small quantity of a light oil. At a dull red heat the distillation of a dark brown oil commenced, and the gas evolved was contaminated with a yellow uncondensible vapour containing much sulphuretted hydrogen.

In order to obtain as much of the liquid and solid products as possible, it was necessary to perform the distillation at a very low temperature. Five hours and a half were therefore necessary to complete the operation.

The product of distillation collected from the receiver and the several Woolfe's bottles, consisted of an offensively-smelling oil of a dark brown colour, suspended in an aqueous liquid charged with sulphuretted hydrogen, carbonic acid, and ammonia.

In order to purify the oil, it was heated with hydrochloric acid, which combined with the ammonia, and disengaged the sulphuretted hydrogen and the carbonic acid which it contained.

When operating upon a large scale, this liquid would yield on evaporation an appreciable quantity of sal ammonia, which, in forming my estimate of the value of the product, should be taken into consideration.

The oil was then submitted to distillation with water, when an *oily liquid*, *a*, heavier than water, passed over, a *tar-like residue*, *b*, remaining in the retort.

A.—Oil.

The oily liquid, *a*, was heavier than water. When just distilled it was colourless and transparent, but turned dark and opaque upon standing. For further purification it was treated with an alkaline liquid, which removed sulphuretted hydrogen, and then once or twice with sulphuric acid. The oil then purified, now exhibited the odour of the finest varieties of coal-gas naphtha; it no longer turned dark on exposure to air and light.

This purified oil is a mixture of several chemical substances. Its compound character is rendered obvious at once by its deportment with concentrated nitric acid, which divides it into two distinct portions: a *portion*, 1, *insoluble in nitric acid*, and a *portion*, 2, *which was dissolved by it.*

1. *Insoluble Portion of the Oil A.*

The portion insoluble in nitric acid floated on the surface of the solution in the shape of a light, colourless, oily liquid. It formed the smaller fraction of oil *a*. It was no longer acted upon by concentrated nitric acid; sulphuric acid, likewise, was without action. In its general character, this oil resembles the hydrocarbon of the Boghead cannel-coal tar oil, and of petroleum.

2. *Soluble Portion of the Oil A.*

The nitric solution, when mixed with water, furnished a dense, heavy yellowish oil, possessing the odour of nitro-benzol *, the aromatic oil which has lately come extensively into use as a cheap substitute for oil of bitter almonds for flavouring soap, &c., and which is extensively produced in France under the fancy name, "Essence de Weirbane," and of late, also, largely manufactured in this country.

The preceding experiments show that the oil, *a*, consists chiefly of benzol and its homologases, mixed with small quantities of petroleum hydrocarbons. When sufficiently purified, it may be used for all the purposes for which benzol is at present employed—for dissolving india-rubber and gutta-percha, for removing stains from fabrics, for preparing varnishes, for preparing artificial oil of almonds, &c.

6. *Tar-like Residue.*

The oily tar-like residue which remained in the retort, when the crude volatile product of the action of heat on Dorsetshire shale was submitted to distillation with water, was *again* distilled, but this time without water.

This required a rather high temperature, which, in the last stage of the operation, had to be increased to a red heat.

The volatile products were collected in two different portions, which, however, were so much alike that a more detailed description of the first portion may suffice. In the retort remained a black pitch-like substance.

The first half of the oil which passed over during the distillation was (when first distilled) of an amber colour, and of an offensive, somewhat sulphur-like smell; it was much less limpid and mobile than the oil procured by distillation with water. When exposed to the action of the air it lost its odour, but assumed a much darker colour.

This oil is acted on by sulphuric acid, by nitric acid, and by hydrochloric acid. These agents, especially sulphuric acid, resinify a portion of the oil.

The remainder, when washed with water and afterwards distilled with steam, furnished a perfectly colourless oil, which, when cooled to the freezing-point of water, deposited small shining crystals of paraffine. The fluid portion from which these crystals are deposited has the properties of liquid paraffine; and the above colourless oil behaves in every respect like the liquid product of the Boghead cannel coal, which is generally called paraffine oil, and may therefore be used for all the purposes (especially for the lubrication of machinery) for which paraffine oil is so extensively employed. Unfortunately, this product forms but a small fraction of the original oil.

II.—Non-Volatile Products.

A.—Coke.

The fixed constituents of the shale remaining in the iron still is a black cokey residue, the nature of which varies with the special character of the variety of shale submitted to experiment. The nature of the coke closely corresponds with that of the ash furnished on complete incineration.

Thus, the coke of the specimens designated in the introductory paragraph as I. and II., retains the shape of the pieces distilled; it is soft and easy to powder, and contains a large quantity of finely-divided carbon, mixed with the inorganic constituents. On the other hand, the coke furnished by Specimen III. (the richest variety) is entirely different, in consequence of the large amount of volatilizable matter this variety gives off through fusion in the first stage of the distillation.

The residue remaining after all the volatile matter has been expelled has altogether lost the shape of the original shale; it is hard, difficult to powder, and resembles in its general character the coke produced from coal in the manufacture of gas.

The peculiar state of division in which this carbon exists in Specimens I. and II., suggested the applicability of the coke for the purposes of discolorization and deodorization. A series of experiments made with the view of testing its efficacy were, however, attended with but very partial success. A decoction of logwood, when brought in contact with the coke, loses, indeed, its colour almost instantaneously; but it was subsequently found that this was due to the presence in the residue, not of the finely-divided carbon, but of the sulphide of iron and sulphide of calcium which the residue always contains. A solution of burnt sugar, which is a much better test, is, in fact, scarcely affected by the coke.

The experiments made for the purpose of ascertaining the deodorizing power of the coke were likewise attended with indifferent results.

The amount of coke contained in different varieties of shale, as well as the quantities of carbon and hydrogen present in them, are given in the synoptical arrangements of the analytical results at the end of the report.

B.—Ash.

The ash of the incinerated coke contains, unless the incineration was conducted at a very high temperature, a certain quantity of carbonic acid, which corresponds to the amount of lime that is present. Hydrochloric acid dissolves a portion of the ash with evolution of carbonic acid, and occasionally sulphuretted hydrogen.

The hydrochloric solution contains—

Lime,
Alumina,
Silica,
Peroxide of iron,
Magnesia,
Oxide of manganese, } traces.
Sulphuric acid, }

The residue, insoluble in hydrochloric acid, consists of—

Alumina,
Silica,
Peroxide of iron (small quantity).

The ash of the Dorsetshire shale, containing, as is seen, an association of constituents similar to that found in Portland, it became desirable to perform a quantitative analysis of it, in order to compare its composition with that of the cement.

On submitting to analysis the ash of the shale, which contains the largest amount of mineral matter, the following results were obtained, which I place in juxtaposition with the corresponding quantities of constituents of a Portland cement remarkable for its qualities:—

		Ash of Dorsetshire shale.		Portland cement.
Insoluble residue		29·01	.....	—
Soluble in hydrochloric acid.	Peroxide of iron	7·10	.....	5·30
	Silica	21·75	.....	22·23
	Alumina	10·60	.....	7·75
	Lime	20·62	.....	54·11
	Carbonic acid	10·92	.....	2·15
		100·00		

It is obvious that iron, silica, and alumina occur in both substances in almost exactly the same proportions. A great deal of the ash constituents are, therefore, in a condition favourable for the formation of a hydraulic cement,; and it is very probable that turning of the ash with an additional quantity of lime might confer upon this ash at once the character of a true cement.

Many other applications will suggest themselves. It is well known that the ash of the Boghead cannel mineral is made largely available in producing the lute for the gas retorts, and the bricks required for the construction of the furnaces.

In conclusion, I unite the numeral results obtained in the investigation in the following tables:—

Distillation of the Shale at a high temperature for the purpose of producing gas:—

Amount of gas, water, ammonia, &c.	63·5
Amount of coke	36·5
	100·0

Composition of the Coke.

	Analysis I.	Analysis II.
Carbon	73·4	72·8
Ash	30·3	30·3
	103·7	103·1

The excess above 100 arises from the presence of sulphides in the coke, which during the process of incineration absorb oxygen, and are converted into sulphates.

Distillation of the Shale at a low temperature for the purpose of obtaining the liquid and solid volatile products:—

Analysis of Specimen II.

Coke	71·5	54·1	Mineral matter
		15·0	Carbon
		2·4	Hydrogen
Oily and solid volatile products	14·6	2·7	Light oil (naphtha)
		9·5	Heavy oil, containing 1·3 per cent. paraffine
		2·4	Residue of pitch
Gas, water, ammonia, &c.	13·9	13·9	Gas, water, &c.
	100·0	100·0	

* The nature of this substance was, moreover, determined by what chemists call the "Analine re-action."

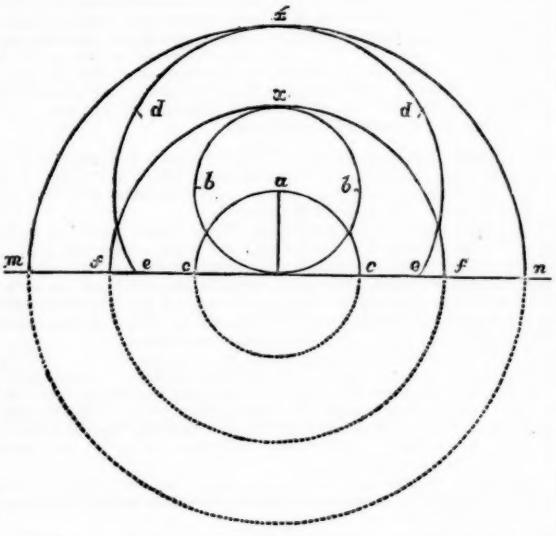
ANALYSIS OF SPECIMEN III.

Coke	43·0	23·5	Mineral matter
		19·5	Carbon
Oily and solid volatile products	39·0	2·3	Light oil (naphtha)
		36·7	Heavy oil, containing 1·9 per cent. paraffine
Gas, water, &c.....	18·0	18·0	Gas, water, ammonia, &c.
	100·0	100·0	

Correspondence.

LIGHTNING CONDUCTORS.

SIR,—Allow me to point out that, if those whom you have lately addressed on the subject should become desirous of protecting their gasholders from mischievous discharges of atmospheric electricity, they need not be driven to have recourse to the foreign science you have recommended. It is true that we have, since 1780, conceded to M. Coulomb the merit of having discovered the law which makes the force of electrical attraction acting at various distances to vary inversely in the ratio of those several distances multiplied into themselves; but that law is just as inadequate to explain the theory of lightning conductors as would be any other inverse ratio of the distance we might assume. What we need much more is a knowledge of a new law that teaches the effects of multiplying quantity, and that I have reason to believe no foreign authority has yet written anything about. Guided by that law, I think I shall be able, with the aid of a diagram, to make the science of lightning conductors quite intelligible, even to those of your readers who have hitherto devoted to electricity little or no attention. I will, however, prepare the way by showing the inadequacy of the instructions issued by the French commission of 1823, as quoted by you, and by which lightning conductors are represented as capable of protecting a building "to a distance bounded by a circle equal to twice its height."



Let the line *m n* in the above figure represent the section of any horizontal iron surface intended to be protected from lightning, and conceive *a* to be a vertical rod of iron rising to any given height above it. Make the base of the rod the centre of a circle whose radius is equal to its height, and make also the summit of the rod the centre of a like circle. Now, as the attraction of a given quantity of accumulated electricity, *x*, is constant at like distances, and increases in some ratio as distance diminishes, it follows that *x* will be equally attracted by the summit of the rod *a*, wherever it may be placed on the semicircle *b x b;* hence, as electricity selects the shortest passage (all other things being equal), lightning falling anywhere upon the semicircle *b x b* will be attracted by the rod *a*, and cannot fall upon the line *m n*. Thus, the part of that line which lies between *c c* is under the the protection of the rod; and, therefore, it may be reasonably announced that a lightning conductor will only protect to a distance bounded by a circle equal to twice its height, *if we assume* that *x* cannot be discharged into *a* at any greater distance than one equal to its own height. But it is practically known that, so long as the electrical accumulation, *x*, and its distance from the summit of *a*, both remain the same, *a* may be shortened without affecting the electrical discharge; in which case, of course, the lightning conductor would be protecting to a distance greater than is bounded by a circle equal to twice its height. To illustrate this, make the base of *a* the centre of three concentric circles whose radii are respectively equal to a single, a double, and a triple length of the rod, and imagine the discharging force of attraction to extend from the summit of *a* to the electrical accumulation *x'*, namely, through a distance twice as great as the length of the lightning conductor, and which is represented by the great segment *e d x' d e:* there will be on either side of that segment a point, *d*, equidistant from the summit of the conductor and the line *m n*, below which point the electrical accumulation, in obedience to the law of distance, will descend perpendicularly to *e e* upon the line *m n*. Now the interval between *e e* represents the length protected by the lightning conductor, and that is greater than can be bounded by a circle equal to twice its height; but the distance is less than four times the height of the conductor by the space *e f* (on either side), which space, as cut off by successive perpendiculars, becomes greater very rapidly as the discharging distance becomes a higher multiple of the height of the lightning conductor.

Not only have we no warrant for assuming that the discharging distance of any given electrical accumulation is equal to the height of the lightning conductor destined to receive it; but, even were we to grant it as an assumption, it would fail in its purpose; for the discharging distance, as ascertained under any given circumstances, remains constant only so long as the electrical accumulation does not vary, but doubles, trebles, and quadruples with double triple, and quadruple quantities of charge: and no one will be prepared to teach that electrical accumulations over a lightning conductor are constant in quantity.

In England, we have better principles of electrical action for our guidance. The theoretical results obtained above should be equally true whatever be the thickness or mass of the lightning conductor; whereas our neighbours, as well as ourselves, are in the habit of pointing the conductors to increase their efficacy. In this, as in many parallel cases, electricians have taken advantage of facts obtained by observation, in anticipation of theory. Whether we diminish a mass of common matter to one-half, and cause it to act on a given accumulation of electricity; or whether, on the other hand, we cause the undiminished mass of common matter to act on a double electrical accumulation, we in either case double the quantity of electricity, relatively, to a unit of quantity of common matter. Now there is a law, originated in this country, by which the electrical force on a mass of common matter varies as the squares of the quantities of electricity acting upon it; and by that law (the distances being supposed equal) the attractive force of the point of a lightning conductor, compared to the force of the end of a bar of iron exposing ten times its mass, must be as $10 \times 10 = 100$ is to 1. If we, therefore, properly dispose and moderately elevate such points above all projecting angles and other parts of a gasholder and its contiguous buildings, we need not be in doubt as to the security they will confer on surfaces comparatively flat.

I have purposely avoided entering further into the theory of electricity than was absolutely necessary for applying it to my subject, but I will extend it just to show that the protection you are recommending is not a work of supererogation. The injury to the gasholder at Brick Lane is the second that is alleged to have been caused in the metropolis by lightning, one having been reported a few years ago at the works of the Independent Company, at Haggerstone; whether both, or either, of the cases have been rightly imputed to electricity, must be decided by those best acquainted with the circumstances and the state of the *débris*, but I may assert with perfect confidence that our knowledge of electrical induction points to the broad crowns of modern gasholders as eminently calculated to act the part of the uninsulated disc of a gigantic Volta's condenser, and thus accumulate over them and in their immediate vicinity an amount of electrical charge which it would not be extravagant to invest with a power great enough to rend asunder even a plate of cast iron in its passage through it.

In accordance with the present state of electrical science in England, I recommend the following simple way for effectually securing gasholders from possibility of accident by lightning. On the top of one or more of the guide-columns fix vertically five 4-feet lengths of drawn iron pipe, progressively diminishing in diameter from 2 inches to 1 inch, previously screwed together, and with a copper rod 18 inches long, sharply pointed, fixed to its smaller end. If there be more lightning conductors than one thus constructed and fixed, they will all be in excellent communication with one another by the conducting nature of the connecting girders; and they may be put into equally good conducting communication with an immense extent of discharging soil by connecting the base of one of the guide-columns with the service-mains by means of a stout iron rod. Under such an arrangement, the crown of the largest gasholder ever likely to be constructed could not be approached by a dangerous accumulation of atmospheric electricity, because, as the radius of the circular area which is protected by a conductor is equal to the radius of a hemisphere of air above its point, to which the electrical attraction extends (as seen in the diagram), it follows that the electricity must silently be attracted away in detail while at a considerable distance, and harmlessly distributed in the earth by the external surface of the first few hundred feet of iron mains.

The number of lightning conductors to be erected above a gasholder is a matter of considerable importance, and will vary with its diameter, its position, and other circumstances. You, Sir, have spoken of an excess in number as a harmless luxury; but it is something worse than that, for—and it is not a little remarkable—

a French *savant* long ago discovered that nine pointed conductors within a certain circumscribed area were less effective than one of them in the absence of the other eight. The new law of quantity explains that each of them may act upon a given electrical accumulation with a force equal only to $\frac{1}{81}$st part of the force exerted on the same accumulation by a single point; and that fact may be applied as a useful commentary on the practice which prevails among us of arming the end of a lightning conductor with a multiplicity of bifurcations.

I must not dismiss this brief notice without explaining the grounds on which the new law of electrical force at present rests. The Hon. Henry Cavendish, so long ago as 1772, and since him Sir W. S. Harris, in 1834, observed during their experiments certain new results of electrical action. These results were referred by the former philosopher to hypotheses posthumously published in 1853, and which are obsolete; and by the latter electrician their direct indication was considered so palpably at variance with admitted doctrines, as to be rejected by him without ceremony. Having, in 1838, repeated and extended the experiments of Harris, I published in the "Philosophical Magazine" for June of that year a series of arguments for viewing their direct indications as the expression of a new electrical law; and subsequently, in a small work entitled "Matter and Force," published in 1851 by Messrs. Taylor, of Red Lion Court, I insisted on the necessity of adopting that new law: at the same time, in proof of its truth, laying open by its help the causes of several distinct classes of phenomena, which, without that law, are still inexplicable. I am continually adding to its evidences, but already there is cause to think my reasoning has to some extent produced conviction, for in 1852, and subsequently to that date, Sir W. S. Harris has spoken publicly of the law as established, and bases his calculations upon it*. RICHARD LAMING, M.R.C.S.

Hayward's Heath, Sussex, September 4, 1857.

MANURE FROM COKE AND GAS LIQUOR.

SIR,—Having noticed the remarks in your JOURNAL relative to the unsaleable coke, in different gas-works, causing much loss, I beg to suggest that, by pulverizing it, and impregnating it with gas-water, it might be made into a valuable manure, the ammonia in the gas-water being fixed by sulphuric acid, &c. When sold to the farmer, in the above prepared state, it would be found very valuable for his grass lands, cereal crops, and his turnips, when drilled in with the seeds; having myself found by experience that Boghead charcoal and soil, impregnated with gas-water, and sown broadcast on the land, conduces to a healthy growth of vegetation. By the use of gas-water, the artificial manure manufacturer increases the value and fertilizing properties of his manure; and in the above simple use of coke, impregnated with gas-water, the necessity of diluting the latter with water, and then putting it on the land with a watering-cart, is done away with, at the same time that the strength of the gas-water does not check the growth of vegetation. The breeze also could be impregnated as well as the coke. The value of ammonia being about £60 per ton, the per centage of ammonia, taken up by a ton of pulverized coke, could soon be ascertained, and its value per ton, for agricultural purposes, determined.

Holmpton Lodge, Sept. 17, 1857. JOHN MALAM.

Register of New Patents.

650.—THOMAS JEFFERSON THOMPSON, of Greenwood Park, in the co. of Down, Ireland, for "*Improvements in the construction of gasometers, whereby they are rendered applicable to lighting railway carriages.*" Patent dated March 5, 1857.

The principal feature of novelty in this invention consists in dispensing with the ordinary mass and weight of water at present used in gasometers of the ordinary construction, as by this invention no more water is required than is sufficient to form an hydraulic packing of about one inch in breadth, so as to prevent all escape of gas during the working of the gasometer. To effect this, the gasometer is formed in the following manner:—A rectangular tank is made sufficient for the supply of water to a locomotive engine. The tank has no lid or opening excepting a funnel, which enters the bottom of the tank from the back part of gasometer, for the purpose of filling the said tank with water. Round the four sides of this tank is put a thin iron sheeting, about one inch from the sides of the tank, and extending above the top of the tank above twelve inches. This sheeting is connected with the tank by a wrought-iron frame, or angle-iron, round the bottom of the tank, to which it is riveted. A space is thus gained all round the tank of one inch in breadth, which is filled with water until the water is about one inch in depth over the top of tank. The movable part of the gasometer is formed so that it works freely up and down in this water space, its working being kept true by means of guide-rods, the bottoms of which are fastened through the wrought-iron foundation-ring (to which the outside sheeting is riveted), and the tops are kept true by means of stays to side-plates. Upon the movable part of the gasometer there are guides, fastened to work upon these rods; the uppermost guide to each rod (which works above the water-level) has a spring catch, which works in a ratchet fixed upon the guide-rod to prevent any jumping of gasometer upon a rough road. The roof of the movable part of the gasometer will be about 1½ inches above the roof of water-tank when no gas is in the gasometer.

By the above mode of constructing gasometers, as the cover descends the water displaced thereby will occupy the space between the said cover and the uppermost part or roof of the tank; so that when the gasometer is again filled with gas, the water will flow off the roof of the tank to supply the deficiency made by the gasometer-cover rising out of the water space. It is also proposed to dispense with the counter-balance weights commonly employed, and to use in lieu thereof guides and spring catches, and the working pressure of the gas in the gasometer will be from two to six inches of water. The sides of the movable part of the gasholder and the outside plates are formed sufficiently high to allow of the rise of the water by pressure. When filling at stations the working pressure of supply gasometers is about 12 inches of water. The supply of water, to suit the variation of pressure, is always preserved; for when the gasometer descends, the water displaced thereby, instead of overflowing (and by so doing rendering it necessary to fill up the deficiency upon the gasometer being again filled with gas), flows over the top or roof of the tank, and flows down as the gasometer rises.

In adapting this improved gasometer to the lighting of railway carriages, the following mode of proceeding is adopted:—The connexion of the different carriages is effected by means of valcanized indiarubber tubes, which are coupled to the cut-off apparatus, which is permanently fixed upon each end of every carriage, and consists in a small branch pipe, which, when the gas is turned on and the carriages coupled, is kept in its proper position by means of a spring; but when any strain comes upon the aforesaid coupling-pipe from the carriages becoming detached, or from other causes, the strain upon the pipe will then draw the cut-off pipe out at right angles to the end of the carriage, and thus turn off the gas. The union-joint upon the end of the pipe cannot be unscrewed without first turning off the gas, as the plate upon which the cut-off pipe is screwed has two wings which project round the union-joint, thereby preventing any possibility of its being disengaged while the gas is turned on in that cut-off pipe.

The claim is for a gasometer of the construction above particularly described, whereby the necessity is dispensed with for employing a large mass and weight of water as at present practised in ordinary gasometers, and also dispensing with the balance-weights as above stated, and also the mode of coupling, as described.

666.—GEORGE HAWKSLEY, of Bromley, Middlesex, engineer, for "*An improvement in constructing apparatus for heating and cooling air, steam, and other fluids.*" Patent dated March 7, 1857.

This invention has for its object an improvement in constructing apparatus for heating and cooling air, steam, or other fluids, when such apparatus consists each of a series of tubes combined together, within or around which tubes the fluid to be heated or cooled circulates; and the invention consists in combining together such tubes, when suitably arranged, into a series, by casting on to them, at or near each of their ends, a plate of metal; and, if the tubes require to be surrounded by an external case, then these plates form the ends of the case, and are cast on to it as well as on the tubes. If the apparatus requires no external case, then to form a chamber at each end of the series of tubes, the plates may be cast with raised rims round their edges, and such rims may be furnished with flanges suitable for receiving covering-plates.

683.—HENRY RICHARD SMITH, of Wellingborough, Northamptonshire, engineer and machinist, for "*Certain improvements in manufacturing and purifying gas made from coal or other bituminous substances for illumination.*" Patent dated March 9, 1857.

These improvements in the manufacture of gas consist principally in the use of a conical-shaped vertical retort, and which shape and position greatly conduces to a more uniform distribution of the heat from the furnace, and thereby effect a thorough conversion of all the gaseous matter with which the retort may be charged, extracting a much larger quantity of gas than can be obtained from the same amount of coal or other matter than is generated in the retorts as at present constructed.

The improvement in the apparatus for purifying gas is in the combination of the hydraulic condenser with the lime purifier; for, inasmuch as (by the use of the retort described above) a larger proportion of the coal or charge is converted into gas, so in proportion is there a smaller quantity of refuse, in the shape of liquid tar, and therefore the condenser is not required so large in proportion to the refiner, as in the case where horizontal retorts are used.

The claim is for the use of vertical retorts for the manufacture of gas, and the combination of hydraulic condensers with the refining apparatus, as herein described.

686.—CARL HEINRICH WILHEM MAXIMILIAN LIEBMANN, of Fartown, Huddersfield, York, warehouseman, for "*Improvements in the purification of water, and the preparation of materials requisite for the process.*" Patent dated March 9, 1857.

Before the proper application of this system, water containing carburetted or sulphuretted hydrogen gases must necessarily be agitated during a period sufficient to remove them, it being indifferent by what kind of mechanical appliance; but it is obvious that the character of this is somewhat dependent upon the quantity of the water to be purified,—minor quantities emit their gases if the vessel is merely shaken during a few minutes; considerable masses may easily be agitated by wheels, &c. River water, however, seldom or never carries those injurious gases, and therefore the said preparatory agitation is not required if water of that kind is the object.

The second step of the process consists in impregnating the water with carbonic acid to one-tenth of its volume. Water-works measure the quantity of the acid, which ascends from one or more pipes at the bottom of the reservoir by a short and practical method.

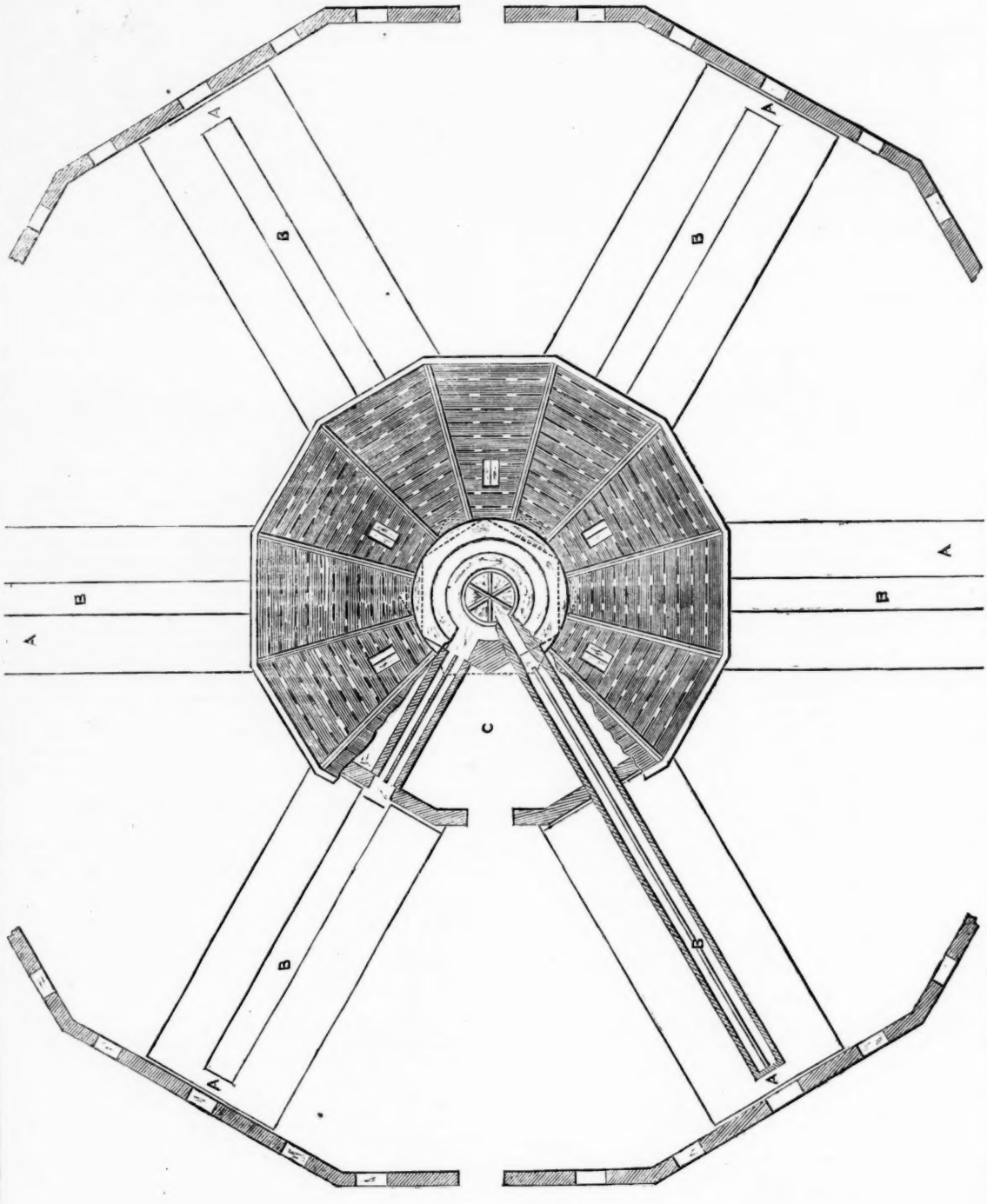
The mouths of the gas-pipes are shut up by a cover perforated like a sieve, compelling the carbonic acid to ascend in minute bubbles: thus the impregnation is easily effected without any considerable loss of gas.

Immediately after the impregnation with carbonic acid, a quantity of hydrate of lime is added to the water, without regard to form, as either powder, cream, or lime-water. The quantity of the hydrate of lime must be sufficient to precipitate all the free carbonic acid, the acid of the bicarbonates originally contained or formed in the water, and, besides, to make the whole bulk of the latter strongly alkaline; much agitation must be carefully avoided while the lime is added.

* See "Rudimentary Magnetism," Part III., page 46.

WESTERN GAS WORKS, KENSALL GREEN.

GROUND PLAN OF RETORT-HOUSE.



A—Retort-Beds. B—Flues from Retorts. C—Receptacle for Coals.

Scale—20 feet to 1 inch.

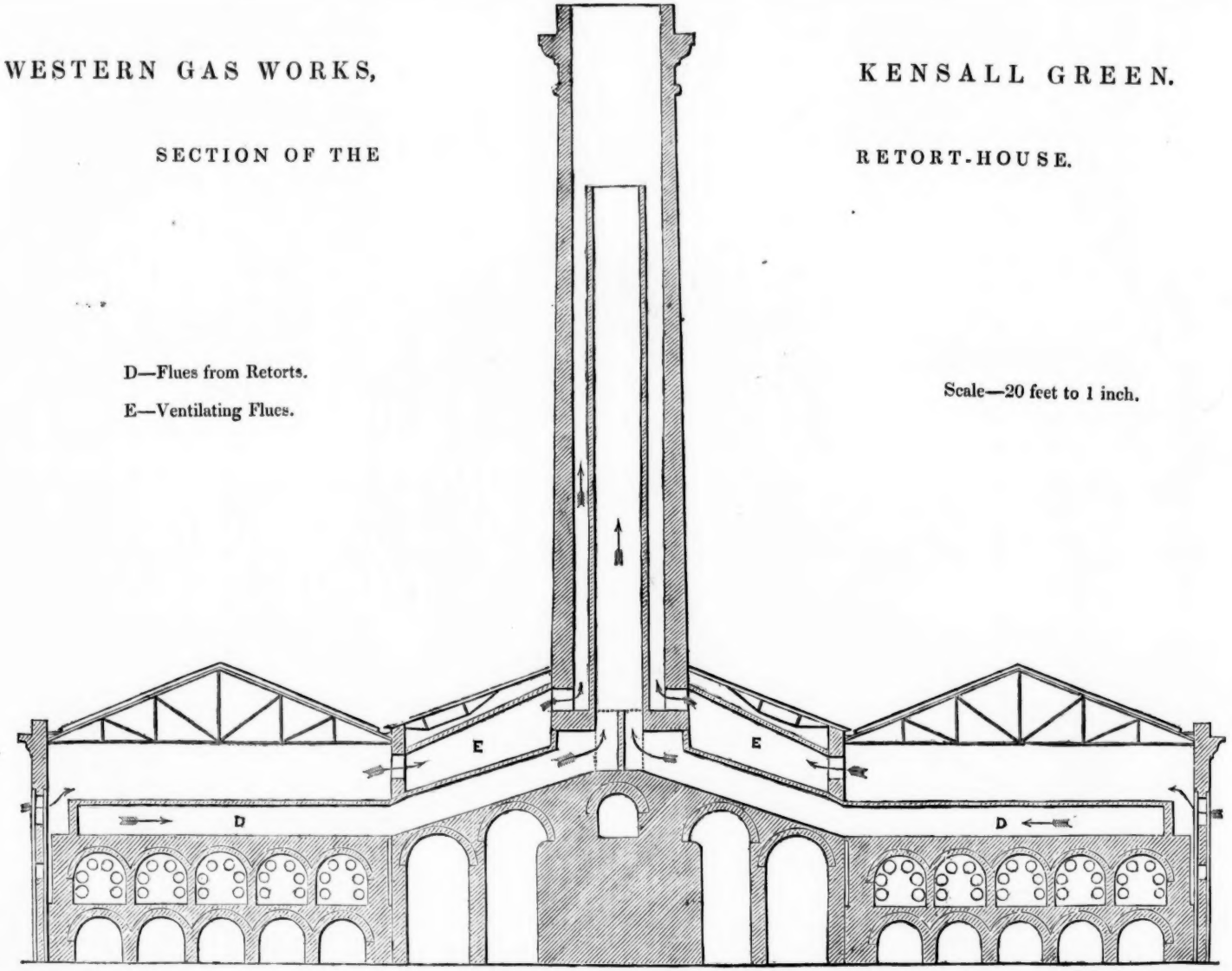
WESTERN GAS WORKS, KENSALL GREEN.

SECTION OF THE RETORT-HOUSE.

D—Flues from Retorts.

E—Ventilating Flues.

Scale—20 feet to 1 inch.



After adding the lime, the water should remain without the slightest agitation for from twelve to sixteen hours, after which time the precipitate has entirely subsided. The water is then led off through a system of pipes, the mouths of which are just above the layer of the precipitate, to a second reservoir, containing gas-pipes of the same construction as those in the first, which discharged the carbonic acid. How much of this gas is required to precipitate the free lime, is easily ascertained by the aid of hematoxyline.

The lime having been precipitated by carbonic acid, the water settles and clears itself within a very short time to a perfect brightness, which far exceeds the transparency of the best spring water. It is then again transmitted through a system of pipes, inserted over the layer of precipitate, into a third receptacle. It is now fit for use, and may or may not again be impregnated with carbonic acid, by pipes of the same construction as those mentioned above.

It is evident that the said impregnation can only take place where the conducting pipes are of earthenware or enamelled iron.

If the water to be cleaned contains any sensible amount of ammonia salts, their basis (ammonia) must be removed before the second current of carbonic acid is allowed to enter the second reservoir, which is effected by agitating the alkaline water in the second reservoir by means of one or two wheels of proportionate diameter and velocity, during more or less than a quarter of an hour. The ammonia evaporates entirely.

691.—ANDREW KNOX, of Mile-End, London, and THOMAS ROBSON, of Aldersgate Street, City, London, engineers, for "*An improved gas-regulator.*" Patent dated March 9, 1857.

This regulator consists of an identical case with apertures for admitting gas from a main, and for allowing it to escape to the burners. Inside the case is a chamber, fitted with a conical valve, suspended as hereafter stated. The inlet aperture leads directly into this chamber, and no gas can pass through the regulator without entering it.

Over this chamber, and at a convenient distance between it and the top of the case, is fitted a diaphragm of oiled silk or other like suitable material. To the centre of the diaphragm is affixed a tapped nut, through which is inserted a screwed spindle, the bottom of which terminates in an eye, on which the valve before named is hooked; or it may be made in a piece with the spindle. Upon the top of the diaphragm a weight is placed, which can be regulated according to the pressure at which the gas is to be allowed to escape from the regulator.

The claim is for the improved gas-regulator hereinbefore described, whereby the pressure of gas in the pipes leading to the burners is made to act upon a weighted diaphragm, connected directly to a regulating-valve, in the manner hereinbefore described, to regulate the supply from the meter or main passing through the regulator to the burners.

708.—JOHN ROBERT REID HUMFRYS, of Salford, in the co. of Lancaster, Master of Arts, for "*Improvements in apparatus for burning gas.*" Provisional protection only obtained. Dated March 12, 1857.

This invention relates to apparatus for effecting more perfect combustion of gas, and to obviate the liability to ignition below that part of the apparatus assigned to combustion. It is applicable to all apparatus used for the purpose of illuminating, heating, cooking, and other purposes, such as the gasing of yarns, the singeing of cotton fabrics, &c. The burners will, therefore, be modified according to the purpose for which they are to be used; and this invention will be applied thereto in a variety of forms, according to particular cases.

One part of the improvements consists in the admission or direction of a current or currents of air (somewhat on the principle of the blow-pipe) to that point from which the gas issues, so as to effect a combination necessary for complete combustion.

Suppose an ordinary argand burner to be employed, a conical chamber, or a series of pipes communicating with the atmosphere, are arranged concentric therewith. The upper orifice or orifices being directed inwards, causes a stream or streams of air to rush upon the gas so as to mingle therewith.

As another illustration of the method of applying the improvement, which has been found to answer, suppose a horizontal pipe, straight or curved, is employed, either perforated with small holes or having a number of burners attached thereto, and situated, if desired, beneath a surface of wire gauze, as in apparatus applied to the purpose of heating. Parallel with these pipes, and on each side thereof, is placed a sheet of metal at an angle, so as to form a section similar to that of the vertical section of a cone. The air entering at the base is gradually directed towards a central line, so as to issue first above the orifice of the burner or perforated pipe, and to mingle with the gas issuing therefrom.

Another part of the invention consists in the use of curved plates, or other apparatus, for imparting one or more angular directions to gas and air before they issue from the burning orifice or orifices, whereby the liability to combustion below the proper level is obviated.

According to another part of the invention, gas and air are caused to pass over contiguous passages so as to be delivered into an outer chamber constituting a reservoir, which may be supplied with wire, gauze, or other apertures constituting burners. Above such passages a surface is applied, interfering with the direct issue of the air and gas whereby the diffusion is facilitated.

713.—JOHN AVERY, of 32, Essex Street, Strand, London, patent agent, for "*An improved method of purifying schistous or bituminous oils.*" A communication from CHARLES CAMUS and JEAN MISSILLIER, of Paris, in the empire of France. Provisional protection only obtained. Dated March 12, 1857.

This improvement consists in submitting the crude or ordinary oils of this class to the action of chloride of sodium, thereby depositing the impurities contained in the oils. The dregs are then drawn off by a tap near the bottom of the vessel in which the operation is performed. The oil is afterwards allowed to stand for about two hours. The process is then repeated until the oil shall have become disinfected or purified.

833.—ALFRED VINCENT NEWTON, of 66, Chancery Lane, London, mechanical draughtsman, for "*An improved construction of water-meter.*" Patent dated March 25, 1857.

A description of this invention without the aid of drawings would be wholly unintelligible.

The claim is for—

1. Two pistons operating in a single cylinder, and actuating the valve without outside connections, in the manner substantially as set forth.
2. The air-chamber between the pistons operating as set forth.
3. For the differential piston, with its spring, constructing and operating in the manner described, for the purpose of completing the throw of the valve.
4. The method of emptying the meter and its dependent chambers and pipes whenever the supply is shut off.
5. For the openings, with their float-valves, for the purpose of permitting the escape of air from the cylinder.

PROVISIONAL PROTECTION

HAS BEEN GRANTED FOR THE UNDERMENTIONED PATENTS.

2203.—EDWARD LUND, of Manchester, in the co. of Lancaster, for "*Improvements in cocks, valves, pumps, and water plugs.*" August 19, 1857.

2302.—ALFRED VINCENT NEWTON, of 66, Chancery Lane, London, mechanical draughtsman, for "*Certain improvements in meters for gas and other fluids.*" September 3, 1857.

2311.—LOUIS MOREAU, of Paris, gentleman, for "*Improvements in apparatus for carbonizing peat, wood, and other combustible matters.*" September 4, 1857.

2322.—RICHARD JOHNSON, of Blackburn, in the co. of Lancaster, gentleman, for "*Certain improvements in purifying and filtering water.*" September 5, 1857.

2403.—WILLIAM MIDDLETON, Jun., iron founder, and THOMAS TERTIUS CHILLINGWORTH, civil engineer, both of Birmingham, in the co. of of Warwick, for "*Certain improvements in adjusting the sliding parts of chandeliers and gas pendants.*" September 16, 1857.

2407.—EMILE ALCAN, of Fore Street, Aldermanbury, London, merchant, for "*An improved process for refining paraffine.*"

INVENTION PROTECTED FOR SIX MONTHS BY THE DEPOSIT OF A COMPLETE SPECIFICATION.

2410.—JOHN SMITH BARDEN, AARON WATKINS, Rockwood, HOLMES HINCKLEY, and DANIEL FRANKLIN CHILD, all of the United States of America, for "*Certain improvements in engines for hydraulic or various other useful purposes.*" September 17, 1857.

NOTICES HAVE BEEN GIVEN OF INTENTION TO PROCEED WITH THE UNDERMENTIONED PATENTS.

1256.—JOHN LESLIE, of Conduit Street, St. George's, Hanover Square, London, for "*Improvements in apparatus for ventilating buildings.*" May 4, 1857.

1353.—JOHN PEAK, of Wigan, Lancashire, manufacturing chemist, for "*Improvements in the manufacture of gas.*" May 13, 1857.

1456.—EDWIN TRAVIS, of Oldham, in the co. of Lancaster, and JOSEPH LOUIS CASARTELLI, in the city of Manchester, in the said co., for "*An improved apparatus for regulating the supply and discharge of steam, air, water, and other fluids.*" May 23, 1857.

Miscellaneous News.

METROPOLITAN BOARD OF WORKS.

REJECTION OF THE B* SCHEME.

At the usual Weekly Meeting of the Board, held on Friday, the 25th inst., the following letter from the First Commissioner of Works was read, and ordered to be taken into consideration at a special meeting of the board on Wednesday, Oct. 7 :—

Office of Works, &c., S. W., Sept. 24, 1857.

Sir,—On the 22nd of December last, the chairman of your board presented to the First Commissioner of Her Majesty's Works, &c., a plan (marked B*) for the main drainage of the metropolis. This plan was forwarded on the 31st of that month to Captain Douglas Galton, R.E., and Messrs. Simpson and Blackwell, civil engineers, who were appointed to consider and report upon the plans for the main drainage of the metropolis, in conformity with instructions to the following effect :—

"*Office of Works, &c., Dec.* 31, 1856.

"Gentlemen,—I am directed by the First Commissioner of Her Majesty's Works, &c., to forward for your consideration the plans for the main drainage of the metropolis, which have been submitted to him for approval by the Metropolitan Board of Works, in accordance with the 18th and 19th Vic., c. 120, ss. 135 and 136. By the first of these sections, it is provided that the Metropolitan Board of Works shall make such sewers and works as they may think necessary for preventing all or any part of the sewerage within the metropolis from flowing or passing into the river Thames in or near to the metropolis, and shall cause such sewers and works to be completed on or before the 31st day of December, 1860, and shall also make such other sewers and works, and such diversions or alterations of any existing sewers or works vested in them under this Act as they may from time to time think necessary for the effectual sewerage and drainage of the metropolis, and shall discontinue, close up, or destroy such sewers for the time being vested in them under this Act as they may deem unnecessary, and such board shall from time to time repair and maintain the sewers so vested in them, or such of them as may not be discontinued, closed up, or destroyed, as aforesaid.

"'And for the purposes aforesaid, such board shall have full power and authority to carry any such sewers or works through, across, or under any turnpike-road, or any street or place laid out as or intended for a street, as well beyond as within the limits of the metropolis, or through or under any cellar or vault under the carriageway or pavement of any street, and into, through, or under any lands whatsoever within or beyond the said limits, making compensation for any damage done thereby as hereinafter provided; and all sewers and works from time to time made by the said board shall vest in them.

"'And the said board shall cause the sewers vested in them to be constructed, covered, and kept so as not to be a nuisance or injurious to health, and to be properly cleared, cleansed, and emptied; and for the purpose of clearing, cleansing, and emptying the same, they may construct and place, either above or underground, such reservoirs, sluices, engines, and other works as may be necessary, and may cause the sewerage and refuse from such sewers to be sold or disposed of as they may see fit, but so as not to create a nuisance; and the money arising thereby shall be applied towards defraying the expenses of such board.'

"And by the second it is also enacted 'that before the Metropolitan Board of Works commence any sewers and works for preventing the sewerage from passing into the river Thames as aforesaid, the plan of the intended sewers and works for the purpose aforesaid, together with an estimate of the cost of carrying the same into execution, shall be submitted by such board to the Commissioners of Her Majesty's Works and Public Buildings, and no such plan shall be carried into effect until the same has been approved by such Commissioners.'

"I am further directed to forward to you copies of the several reports presented by the engineer of the Metropolitan Board of Works, which reports contain drawings and sections not merely of the plan B, but of other plans.

"I am also directed to send you the enclosed copies of two letters from Captain Burstal, in reference to the flow of the tide in the river, which may be useful in your investigation; the first of those letters is dated July the 30th, and the second November the 18th, the latter having been addressed to the First Commissioner under the following circumstances:—

"In the month of June last the Metropolitan Board of Works submitted to the First Commissioner a plan having an outfall for the discharge of the sewerage into the Thames within the metropolis. This plan was at variance with the provisions of the statute contained in the clause to which I have already directed your attention, and was accordingly rejected by him. On the 5th day of November another plan was submitted by that board, having an outfall so near to the metropolitan boundary that the sewerage would necessarily return to the metropolis. This plan, having been also rejected by the First Commissioner, he directed Captain Burstal to report to him what he considered to be the nearest points to the metropolis at which the sewerage could be discharged so that the provisions of the Act might be complied with. Captain Burstal fixed these points about one mile above the town of Erith, on the south side of the river, and at Rainham Creek on the north side, being a distance of about 15 miles from London Bridge.

"The Metropolitan Board of Works have adopted these points for the outfalls, and have so far complied with the Act. The First Commissioner wishes you, therefore, to consider all the details of the plan in relation to such outfalls; and he desires me to direct your attention especially to the fact, that in the reports presented to the Metropolitan Board of Works, and the statements made to him by the engineer at an interview reported in the morning papers of the 21st of November last, there are great discrepancies as to the amount of sewerage which is discharged.

"It will, therefore, be necessary for you to obtain accurate information upon this important point, as the sizes of all the drains and reservoirs must necessarily be determined by the quantity of sewerage.

"The First Commissioner wishes also that you should not confine yourselves merely to the plan submitted by the Metropolitan Board of Works. He desires to have the fullest information you can afford him; and, if you can devise any other scheme which may, in your opinion, be better calculated to carry out the object in view, he requests that you will in your report set forth that scheme, in order that he may lay it before the Metropolitan Board of Works for their consideration.

"The plans now sent to you fix the outfalls at the points already indicated; but, inasmuch as it is desired by the inhabitants of towns bordering upon the river below the 15-mile point that the main sewer should be extended, and that the outfalls should be placed at a greater distance from the metropolis, provided funds are obtained for the purpose of meeting the increased expenditure, the First Commissioner wishes you to report upon any such more distant points of discharge as may fairly meet the requirements alluded to; and when you submit to him the plans for effecting that object, you will set forth the increased cost consequent upon the extension of the works, the benefits (if any) to be derived by districts through which the extended main drain may pass, and how far those districts should contribute to the cost of such extended works. The First Commissioner feels sure that you will give to the various plans which will doubtless be laid before you such attention as they may deserve. A commission is about to be appointed to inquire into the most effectual means of distributing the sewerage of towns, and of applying it to beneficial and profitable uses; and it may, therefore, be desirable that you should put yourselves in communication with that commission, as a strong feeling seems to be entertained by members of the Metropolitan Board of Works and others that the sewerage of the metropolis may be made a source of profit.

"In conclusion, I am directed to request that you will report your views upon the question of the main drainage of the metropolis, and the points of outfall, at the earliest period consistent with the full consideration of so important a subject.

"I am, &c., (Signed) "ALFRED AUSTIN, Secretary.

"Capt. Douglas Galton, R.E.
"J. Simpson, Esq., C.E.
"E. Blackwell, Esq., C.E."

A copy of these instructions was sent upon the same day for the information of your board.

On the 31st of July last the First Commissioner received a report from the engineers to whom the instructions were given, and a copy of that report was forwarded to your board on that day.

The appendix and plans referred to in that report were not then ready, but they were received here yesterday evening, and I am now directed by the First Commissioner to forward them to you to be submitted to the Metropolitan Board of Works.

In sending in a complete form the report of Captain Galton and Messrs Simpson and Blackwell, with the appendix and plans, I am directed by the First Commissioner to request the consideration of your board to the propositions thus laid before them, which, having been maturely considered and recommended by such eminent engineers as the gentlemen to whom this important question has been referred, must be well worthy of attention.

I am also directed to inform you that the First Commissioner does not approve of the plan B*.—I am, &c.,

E. H. Woolrych, Esq. (Signed) GEORGE RUSSELL, Assistant Secretary.

MARYLEBONE VESTRY, SEPT. 26.

ARRANGEMENTS BETWEEN THE GAS COMPANIES.

At the usual Meeting of the Vestry, held on Saturday last,

Mr. GREENWELL reported that the contract with the Equitable Gas Company for lighting a portion of the parish of Marylebone, terminated at the end of the present year.

Dr. BACHHOFFNER wished to be informed if any notice had been served on the vestry clerk or the authorities of that parish, with reference to the recent amalgamation of the gas companies.

Mr. GREENWELL said he believed that nothing had taken place affecting the parish of Marylebone. He had understood that there had only been some arrangement come to between the Imperial and the London Gas Companies.

Dr. BACHHOFFNER said the grand question was whether this amalgamation would not result in a perfect gas monopoly, and cause the price of gas to be raised, or its quality to be deteriorated, to any extent the companies might think proper. Already a most arbitrary and unjust proceeding had taken place with regard to these gas companies and the consumers. The extensive establishment over which he presided (the Colosseum) had been handed over by the London Company to the Imperial, although they had to pay a large sum annually for gas, without consulting them as consumers, and whether they liked it or not.

Mr. WINGFIELD, so far from being displeased, was delighted that the gas companies had taken this suicidal step, for it would now afford a fair ground for another company to come in.

Mr. D'IFFANGER, jun., would be exceedingly glad to find another company coming in, but he was sadly afraid they would be doomed to disappointment in that matter.

Mr. CARR said the vestry had to thank itself that they had no competition in gas, for they gave very little encouragement to competition when offered a few years ago, refusing to allow a company which offered it permission to lay down their pipes in the parish.

Mr. GREENWELL, in answer to a question, said the Equitable Company at first undertook to light the public lamps of a small district of the parish at £3. 11s. per lamp, but subsequently they undertook their last contract at £3 per lamp.

Mr. FREETH said it appeared that the metropolitan gas companies were playing just the same game as the water companies played with the people of the metropolis some years ago. They had parcelled out the metropolis into districts, and the result had been a most fearful and shameful monopoly on the part of the water companies. They would shortly have the same result on the part of the gas companies, unless public bodies like that vestry took the matter up. (Hear, hear.) Such proceedings were not only opposed to the spirit of the new Act of Parliament under which the metropolis was placed, but opposed to the spirit of the times. Powers were given to parishes to erect their own gas-works and supply the public; and the question now arose as to whether it was not time for the metropolitan vestries to take the bull by the horns and make their own gas. (Hear, hear.) It would, he thought, be advisable to appoint a special committee on this important subject.

Mr. GLIDDON thought a committee, as suggested by Mr. Freeth, very desirable; but he very much feared that, if their object was to bring in any other company to compete with the Imperial, they would do no good. He had no faith whatever in competition, for, as the result had invariably proved, it had ended in combination. (Hear.) In the city of London, as they all knew, some few years ago there was a great gas fight, and a gas consumers' company was got up, and now he believed they had come to an arrangement with the other companies. They did know that corporate towns made and supplied their own gas, and the profits went in support of the other rates, but how far they would be able to carry out that principle in the metropolis was a question.

Mr. BELTON hoped that the vestry of Marylebone would use every exertion to prevent monopoly, and consequent rising of the price of gas, by these gas companies' amalgamations. It was competition at Knightsbridge by the London Company which caused the Imperial Company to reduce its gas to 6s. or 7s. per thousand, while at the same time they were charging the Marylebone consumers, where there was no competition, 12s. per 1000. He was one of the humble causes of the diminution in price. He was quite convinced, if the parishes united and erected their own gas-works, they could borrow money, payable over twenty years, and they could make gas at 1s. 6d. or 2s. per 1000 feet. He hoped and believed the consumers of the metropolis at large would come forward and support them in carrying out this object.

Professor MARKS thought there could be little objection to the appointment of a committee on this subject, but he did not see the policy of the speeches which had been made upon the subject. (Hear.) If they publicly told the existing companies that they meant to get up opposition companies, or erect their own gas-works and make their own gas, and they happened to fail, they would only incense the companies, and be more at their mercy. Neither could he (Professor Marks) see his way quite so clear as to the propriety of that or other vestries turning trading companies. At all events, he considered it premature that they should throw out threats of the kind. (Hear.)

It was ultimately resolved that Mr. Greenwell write to the Equitable Company to know if they were prepared to renew their contract at the present price.

FIRST REPORT TO THE STEAM COLLIERIES ASSOCIATION, NEWCASTLE-UPON-TYNE,

ON

THE USE OF THE STEAM COALS OF THE "HARTLEY DISTRICT" OF NORTHUMBERLAND IN MARINE BOILERS.

Gentlemen,—1.—The length of time that has elapsed since you confided to us the task of awarding the premium of £500 which you offered, in 1855, for the best method of preventing smoke during the combustion of the coal of your district in marine engine-boilers, has been so great, that we feel called upon to address you on the subject, although we are not yet in a position to report finally thereon.

2.—The experiments which it was necessary to make required much time, as well as the construction of apparatus specially destined for the purpose; and at a very early period we became convinced that the only way in which we could satisfactorily decide the question referred to us was to submit the designs brought before us, or such of them as we thought suitable, to trial on a boiler of the ordinary construction employed in steam vessels.

3.—Our first step, therefore, was to have such a boiler built; then to ascertain its effective power as a standard whereto to refer the effects of the various smoke-preventing systems; and, finally, by a comparison of these results with such standard, to determine how far any of them, and, if any, which of them, were entitled to the premium.

4.—We much regret that we are still unable to come to a final conclusion on this matter; but, as in the course of our experiments we have arrived at some facts which we think it important to your interests to be made known, we beg to lay them before you, reserving to a future, and we trust not a distant, period a more complete report upon the whole subject.

5.—The results obtained establish the following facts:—

1. That the coal from your district, commonly called the "Hartleys," may be consumed in ordinary multitubular marine boilers without making any smoke.
2. That this may be done without the adoption of any of the various schemes which have been brought before us.
3. That it does not involve any loss of power or economy, but that with a given boiler *more* water may be evaporated, whilst no smoke is made, than can be evaporated with the hardest firing on the usual system, accompanied by a dense black smoke; and, further, that the economic effect, or the quantity of water evaporated by 1 lb. of coal, is greater when no smoke is being made, to the extent of from 17 to 22 per cent.
4. That the combustion of the coal is perfect, and its evaporative power far beyond what has usually been ascribed to it.

6.—The first two statements are proved by the evidence of the senses, and we can appeal to numerous eye-witnesses of the operations at Elswick for their confirmation.

7.—The third and fourth are proved by the results of the experiments, which may be thus stated:—

FIRST SERIES.

Work done.	Hard Firing. Much Smoke.	Hard Firing. No Smoke.
	lbs.	lbs.
Coal burned per square foot of fire grate per hour	18·50	21
	Cub. Feet.	Cub. Feet.
Water evaporated from 60° Fahr. per square foot of fire grate per hour	2·197	2·932
Total evaporation per hour from 60° Fahr.	60·5	83·5
	lbs.	lbs.
Water evaporated from 212° Fahr. by 1 lb. of coal	8·61	10·10

Showing *an increase of work done of* 38 *per cent., and a superior economy of fuel of* 17 *per cent., whilst making no smoke.*

8.—In the above series of experiments we had:—

Area of fire grate . . . . . 28½ square feet.
Heating surface (total) . . . . . 749 "
Ratio of fire grate to heating surface . 1 to 26¼.

9.—After this, an alteration was made in the boiler. The fire grate was reduced, and an apparatus attached, by means of which the feed-water wa partially heated by the waste gases of the chimney, making the proportion as follows:—

Area of fire grate . . . . . 19¼ square feet.
Heating surface boiler 749 square ft.
Heater . . . . . 320 "
1069 "
Ratio of fire grate to heating surface . . . 1 to 55½

10.—The following table gives the results:—

SECOND SERIES.

Work done.	Hard Firing. Much Smoke. lbs.	Hard Firing. No Smoke. lbs.
Coal burned per square foot of fire grate per hour	21	17·34
Water evaporated from 60° Fahr. per square foot of fire grate per hour. 9	Cub. Feet. 2·909 Cub. Feet.	Cub. Feet. 2·937 Cub. Feet.
Total evaporation per hour from 60° Fahr. .	56 lbs.	56½ lbs.
Water evaporated from 212° Fahr. by 1 lb. of coal	10·06	12·27

Showing *an increase of work of* 1 *per cent., and a superior economy of fuel of* 22 *per cent., whilst making no smoke.*

11.—We have, therefore, no hesitation in saying, that the coals known as "Hartleys" may be consumed in ordinary multitubular marine boilers *without smoke, and with a large saving of fuel resulting from its prevention.*

12.—The evaporative power of the coal, as above stated, is much beyond what is usually attributed to it, and this fact will doubtless be the more gratifying to you, as it may serve to correct an error of opinion which has resulted from the published "Reports on Coals suited to the Steam Navy," with the high sanction of the names of Sir H. de la Bèche and Dr. Lyon Playfair.

13.—In these reports the evaporative power of the coal under consideration, is stated at 7·495 lbs. of water evaporated from 212° Fahr. by 1 lb. of coal, and of the Welsh coals, on an average of 31 kinds, at 9·24 lbs. of water per lb. of coal—the best of the Welsh coal being 10·37 lbs. per lb. of coal.

14.—Some part of the great difference between these and our own results may doubtless be attributable to the different circumstances under which the coals were tried, but we submit that the results we have arrived at (the experiments being made with a boiler of the ordinary multitubular construction, as generally used for marine engines) are, *as practical data*, superior to those made by the Government officials on a much smaller scale, and with an apparatus such as is never used for marine purposes.

15.—We were not, indeed, called upon to pronounce upon the comparative values of the Welsh and north country coals, but, seeing the startling discrepancy between our results and those of the Government experiments, amounting to no less than 65 per cent. as regards your coals, we have felt it necessary to make actual trial of the Welsh coal in the same boiler.

16.—These experiments are still in progress, and in our next report we hope to give the details, and to discuss fully the whole question.

17.—We are at present, however, able to state, that under the most favourable conditions, the Welsh coal *does not exceed the Hartleys either in the amount of work done in a given time, or in economy, and under the general circumstances of steam navigation, falls short in both particulars.*

18.—It will give us great pleasure if in our next report we are able to announce a still higher evaporative power in the north country coals, resulting from some one or more of the plans for smoke prevention submitted to us; but it is only right to state that from the analysis of the gases escaping from the chimney during the above-recorded experiments, we can scarcely anticipate any considerable increase of calorific effect beyond what we have already obtained.

W. G. ARMSTRONG, F.R.S., M. Inst. C.E.
JAMES A. LONGRIDGE, M. Inst. C.E.
THOS. RICHARDSON, M.A., Ph. D., F.C.S.,
Professor of Chemistry in the University of Durham.

GENERAL CONSIDERATIONS ON THE MATERIALS EMPLOYED IN BUILDINGS ERECTED IN SEA-WATER.

(*Continued from page* 399.)

Computation of the Alumina, Silica, and Lime in Combination.—Chemical analysis gives a sufficient approximation for the silica and for the alumina soluble in nitric acid, and in an alkaline solution. In the cases in which the residue, after the treatment by the acid, contains a notable proportion of clay, it is probable that part of the silica and alumina computed may proceed from that clay, and, therefore, the numbers obtained have no certain references to the useful combinations. This uncertainty is greatly diminished, or altogether got rid of, when the mortar does not contain any considerable proportion of clay; but in this case, which is the most favourable for the interpretation of the results, we cannot ascertain in what state the alumina is found: it may be combined simply with the lime, or at the same time with the silica and the lime.

As regards the lime in combination, it is ascertained by deducting from the total quantity the different proportions given by the other operations; consequently, its calculation is also attended with uncertainty.

Computation of the Magnesia and Oxide of Iron.—The determination of the magnesia is a subject of very great importance, particularly if we can compare the analysis of the mortar itself with that of the materials entering into its composition. An increase in the proportion of magnesia would betray the action produced by the salts contained in the sea-water. In this case, it would be difficult to determine in what chemical condition the magnesia would present itself; it might be in the form of hydrate, precipitated by the free lime, or in the form of aluminate, proceeding from the double decomposition of the aluminate of lime of the mortar, and the sulphate of magnesia of the sea-water. We cannot, therefore, regard the magnesia as one of the active elements in the setting, until we have compared and examined the results of the analyses of the mortar, and of the hydraulic cement or lime employed.

The presence of peroxide of iron in any considerable quantity is sufficiently embarrassing, because we cannot tell in what state it may be found. In hydraulic limes and cements, it may be either inactive, or else combined with silica, alumina, and lime; after hydration, and in the presence of a more or less excessive proportion of lime, it probably becomes an almost useless ingredient in mortar, forming with the lime an imperfectly-defined compound of but slight durability.

From the foregoing description, it will be seen that the results given by the analysis of the mortar should be subjected to rigid examination, and that they should often be considered as mere approximations: we should, consequently, be careful not to draw too precise conclusions from the examination of a small number of specimens. Thus, for example, in order to determine the chemical composition of the hydrosilicates which have become solidified, and resisted the action of the sea for several years, we must increase the number of our analyses, and determine the required composition from the results obtained from a long series of specimens. We shall shortly show the application of this in the case of the mortars made from the Theil lime, and employed in the port of Marseilles.

4. *Analysis of the Puzzuolanos.*—The use of puzzuolanos mixed with lime, in marine constructions, seems to date from a very remote period; and many of these constructions are still in very good preservation. At the present day, these mixtures are employed with success in certain situations; whilst, on the other hand, they have in some places given unsatisfactory results. The success of mortars composed of puzzuolanos and rich limes depends, in fact, on the chemical composition of the materials employed, and especially on the observance of the minute precautions required in their application.

In Holland, where these mortars are frequently employed, it is the practice not to immerse the materials until after an interval of preparation of greater or less duration, during which the complicated actions of the lime on the puzzuolano may be completely developed, as it is necessary that they should precede hydration. In the ancient authors we find no mention of this protracted preparation; but it was very probably adopted, because Vitruvius (lib. xi., c. 5 and 6), even in the case of constructions on land, points out the necessity of slacking the lime some years in advance.

Two kinds of puzzuolano are at present employed; the natural and the artificial.

The natural puzzuolanos are rocks of volcanic origin; the most esteemed kinds are procured from Italy, and from Andernach, on the banks of the Rhine. They contain silica, alumina, lime, magnesia, oxide of iron, some alkalis, and water; they possess the common property of being easily attacked by acids and alkalis, and yielding to those agents of the humid process a large proportion of silica.

It may be considered as almost certain that, in mortars composed of puzzuolanos and lime, the setting is attributable to the gradual action of the lime on the silica and alumina of the puzzuolano, and the formation, entirely in the humid way, of the hydrated silicate and aluminate of lime. Beyond this it is impossible to determine within what limits this action of the lime would take effect, as it also is impossible to define the part played by the alkalis found in the puzzuolanos. Chemical analysis is powerless to explain all the questions arising out of the employment of these materials.

The performance of a complete analysis of the puzzuolanos, recognized as valuable in practice, can only be considered useful with a view to preparing information for the future, which would be valuable at the time when science should have attained to the solution of questions which are at present very obscure. At present, it would be necessary to ascertain the proportions of silica and the alumina on which the lime would act. This experiment might be conducted in two ways:—

1. By steeping for a lengthened period, in a suitable quantity of water, the lime and the puzzuolano, intimately mixed together; and afterwards endeavouring to discover by analysis the proportion of silicate on which the lime has not acted.

2. By treating the puzzuolano with nitric acid, evaporating it to dryness, treating it again with the acid, and determining the proportion of silica reduced to the gelatinous form.

The former method is too long to be employed advantageously; and besides, it would be difficult to distinguish the hydrosilicate by analysis, in presence of a portion of the puzzuolano yet untouched by the lime, but exposed to the attacks of the acids and alkalis.

The second method is attended with the great inconvenience of its being insufficient to determine the proportion of silica and alumina which might combine with the lime; and of its giving merely an indication of the facility with which the substance of the puzzuolanos is attacked by the ordinary agents of analysis of the humid kind. There can, indeed, be only a very uncertain relation between the action of the nitric acid and the potash in the laboratory and that of the lime in application; we can only assume that the puzzuolanos most easily attacked by acids and alkalis would also be those most readily accessible to the action of the lime. It follows from this, that, at the present time, the actual application of puzzuolano mortars is the only way of ascertaining their real value; and that we can only expect from analysis some indications of the probable activity of these materials. We have, therefore, made but very few analyses of natural puzzuolanos by measuring the soluble bases in nitric acid, and determining the proportion of silica rendered gelatinous by the action of the acid and soluble in a weak alkaline solution.

We ought in this place to mention, as a natural puzzuolano, a peculiar form of silica entirely soluble in a solution of potash—a tolerably extensive deposit of which appears to exist in France (*a*). The exact locality has not been pointed out to us; but the person who sent a specimen to the analytical department of the *Ecole des Mines* assured us that it was procured from a bed of great extent in the middle of France. We recommend this circumstance to the attention of engineers, because this substance would evidently be the most energetic of all puzzuolanos; and its employment would at the same time present less difficulty and greater certainty of success, on account of the simple nature of the actions produced.

For many years, various kinds of clay, more or less pure, and either raw

(*a*) No doubt the formation here referred to is the "gaize" of the Ardennes, described by MM. Sauvage and Buvignier in the *Statistique Géologique des Ardennes*, (8vo, Mezières, 1842); by M. Vicat in the *Annales des Mines*, p. 527 (1845), and in the *Annales des Ponts et Chaussées*, p. 127 (1846); and by M. D'Archiac in *l'Histoire des Progrès de la Géologie*, vol. iv. (1851). It is singular that MM. Chatoney and Rivot should still speak of it with so much uncertainty after public attention had been thus frequently and officially called to the existence and to the composition of the deposit. MM. Vicat and D'Archiac give the composition of the gaize as follows:—

Water	0·08
Gelatinous silica	0·56
Chloritic sand	0·12
Clay	0·07
Fine quartzose sand	0·17
Total . . .	1·00

This is evidently, both geologically and chemically, the same deposit as the silica beds described by Messrs. Way and Payne as occurring at the base of the cretaceous formation near Farnham. There seems to be good reason to believe that some practical use will shortly be made of a material so valuable and so long neglected.—G. R. B.

or burnt, have been used under the name of artificial puzzuolanos. The results have not been satisfactory in a considerable number of cases. Raw clays are generally much less easily attacked by acids and alkalis than the natural puzzuolanos; and, consequently, the action exercised on them by the lime, when in contact with water, would only be partial and very gradual. It must be still more difficult to employ these compounds of clay and lime; because the partial setting, which takes place after a certain interval, is succeeded by the incessant action of that portion of the lime which is still free on the clay; and from this must arise molecular movements which invariably produce the gradual disintegration of the mortar.

Pure clays, used as puzzuolanos after burning, are under analogous conditions; and, consequently, can only warrant the expectation of successful results in exceptional cases, and under the express condition of rigid precautions in their use. Moreover, the ferruginous and calcareous clays, after being exposed to a prolonged calcination, cannot be regarded as puzzuolanos, as they contain combinations of lime with silica and alumina, together with clay, on which the lime may still act in the humid way. In the employment of these compound substances with a certain proportion of lime, the actions are necessarily very complicated; for it must of necessity be a difficult matter to regulate the setting of compounds formed in the dry way, which have only to become hydrated, and of those which have to be formed entirely in the humid way, and whose formation is progressive.

For all these reasons, clays, whether raw or burnt, cannot in general act as good puzzuolanos; and we do not think it necessary to stop to point out the methods of analysis.

It would seem more rational to endeavour to make use of the slag of smelting furnaces, the scoriæ of iron-works, and the other analogous artificial silicates; that is to say, those which are easily and completely attackable by the agents applied in the humid way. It is certain that lime in suitable quantity, intimately combined with them, would act equally under water, and give rise to hydrated compounds which produce the setting. It remains to show by experience what precautions are necessary in application (*b*).

We have collected in the tables appended to our notice the results of the analyses of a certain number of different materials.

Table A contains the composition of the limestone and the hydraulic lime of Theil, many quarries of which are in full work; also of several of the calcareous beds of Fécamp, as yet unworked, and of the cement stones of Vitry le Français.

In Table B we have collected the analyses of the hydraulic limes of Theil, and of Graville, near Hâvre; and those of some slow-setting artificial cements. We subjoin to these the cements of Vitry le Français. We have selected these as specimens of quick-setting cements, in preference to the better known cements of Vassy, &c., because we have been able to procure a larger number of samples of the Vitry stones and the cements made from them. The two tables, C and D, contain the analyses of a variety of samples of concrete and mortar, made from the Theil lime and the Portland cement, successfully employed at Marseilles and Cherbourg.

In the last table, E, we give the composition of some of the puzzuolanos.

§ 3. *Theoretical Considerations on the part acted by the Silica, Alumina, Oxide of Iron, Lime, and Magnesia, in Hydraulic Materials; and on the Chemical Actions which precede and follow the Setting of Mortar.*

Before commencing the examination of the analytical results contained in the above-mentioned tables, it is necessary to investigate the useful properties of the bodies which enter into the composition of hydraulic limes and cements. It will then be easy to point out the chemical compositions which would ensure a permanent setting, and also the precautions to be taken in the preparation and application of the mortar.

Silica presents itself in the argillaceous limestones, and generally in the natural stones employed in the manufacture of mortars, under two very different forms—in the form of quartzose sand, or in combination with alumina or various bases.

The quartzose sand remains entirely unaffected by humid action, and consequently its effect on mortar is purely mechanical. It is not so, however, with the flints of the chalk, which might be thought to resemble quartz, for this substance is capable of entering into combination with the lime under water; its action is very slow, but not the less certain, and may be of great service in marine constructions. In a theoretical and practical point of view, flint is the intermediate between quartz and the silica which is entirely soluble in the alkaline solutions of which we have before spoken.

In the dry way, quartz, silex, and silica would combine with lime and almost all the bases, with a facility greater in proportion as the mixture was intimate. With the bases, silica acts always as an acid, feeble under ordinary temperature, but whose energy would increase as the temperature rose.

In contact with water, the silicates of lime and magnesia may combine with definite proportions of water, and produce insoluble hydrates of considerable durability.

But silica, under humid action, is a very weak acid, which may be partly, or even altogether, displaced from its combinations by a large quantity of water. This fact has been proved by the alkaline silicates; it may also hold good with respect to the combinations of silica with lime and magnesia, but we do not remember any precise experiments in support of it. Prudential considerations, therefore, should put us on our guard against the possibility of a decomposing action of the water on the silicates of lime and magnesia. If it take place at all, it must be very slow in the case of the silicate of lime, and next to nothing in that of the silicate of magnesia, on account of the small degree of solubility possessed by the lime, and the still smaller affinity which exists between magnesia and water.

Clay and the silicates generally are partially attacked by the acids and alkalis in the humid way. We need only consider here the action of lime; and, in order to avoid complicating the question, let us take the most simple case—a mixture of lime and clay.

The excess of lime, acting in the presence of water, displaces the alumina in order to combine with the silica and form a hydrated silicate of lime; whilst at the same time it combines with the alumina to produce an aluminate which is equally hydrated. These actions are entirely theoretical; that is to say, they are such as ought to take place from the known properties of the silica, the alumina, and the lime. The action is progressive, and can only be terminated after a long period, which varies within very wide limits, from a few months to several years, according to the conditions of the chemical and physical nature of the clay, the excess of lime employed, the closeness of the mixture, and especially of the excess of water, which tends to dissolve the lime, and consequently to diminish its action.

We must not stop at the formation of a silicate of alumina and lime, because the alumina acts as an acid in the presence of a more energetic base. It has been clearly proved by experience, that the moment the clay is attacked, the silica and alumina would act on the lime according to their several affinities. The only uncertainty which can exist has reference to the possible combination of the silica with tho aluminate of lime. Chemical analysis appears to us to be incapable of solving this doubt, which in reality possesses no real importance in practice.

Let us now inquire what may be the gradual action of water on these two compounds, the silicate and aluminate of lime, either isolated or in combination. Alumina being an acid still more feeble than silica is more easily displaced by water from its combination with the bases; and, consequently, it is probable, that, in the course of time, the water would carry off at least a part of the lime from the alumina. In support of this we might quote direct experiments made in the laboratory. When alumina is precipitated in presence of the salts of lime, it carries off, under the form of chemical combination, a proportion of lime, small, according as the liquid is more or less diluted; from which we conclude, almost certainly, that water in considerable excess would also carry off lime from the aluminate of lime.

It follows from the above:—

1. That in mortars formed of mixtures of lime and clay, we cannot expect a solid and permanent setting, unless the chemical action of the lime on the clay is completed previously to immersion; that is to say, it would be indispensable to steep the mixed ingredients, for a long period, in a quantity of water sufficiently great to facilitate the chemical action, but not enough to cause the formation of hydrated silicates and aluminates.

2. That mortar of this nature, prepared with every requisite precaution, and having set well after immersion, would, if permeable by water, contain in itself a source of gradual disintegration—viz., the dissolving action of the water on the lime of the aluminate; to which should be added those of the carbonic acid and salts of magnesia contained in the sea-water. The preservation of the mortar, then, would require that the water should not easily percolate through it, and draw fresh mineral supplies from its inner substance. Such mortar should therefore be compact, or protected by an outer coating of carbonate of lime, shells, sea-weed, &c.

Mortars composed of lime and puzzuolano would give rise to actions still more complicated, to which we shall shortly recur; the more important ones are those which we have before considered in the case of the clays, and, consequently, the same precautions are indispensable in the preparation and application.

In this manner, by simply considering the theoretical properties of the silica, the alumina, and the lime, we are at length enabled to point out the precautions recognised as indispensable in practice for the puzzuolano mortars, and which were very probably more extensively followed by the ancients than they are in our own days in Holland.

Let us now proceed to the dry way. We shall have two cases to examine. 1. *Limestone intimately mixed with quartzose sand in fine grains;* 2. *Argillaceous limestone.*

Case 1.—By the calcination of a limestone containing fine sand, the carbonic acid is expelled, and the lime combines with the silica in the form of a silicate of lime; the action is the more rapid and complete in proportion as the mixture is intimate and the grains of sand fine. The product of the calcination would therefore contain silicate of lime, caustic lime, and also sand in an inactive state, and carbonate of lime in cases where coarse-grained sand is present, or the calcination is imperfect.

In the presence of water, when the sand and carbonate of lime remain inactive, the silicate of lime would combine with the water more or less rapidly, according as the temperature was more or less elevated during the calcination. The excess of lime would also combine with water, and dissolve, at least in part. The preservation of the mortar would depend principally on the excess of free lime remaining with the hydrosilicate, for the action of the sea-water and its salts would certainly take effect on this lime before they could attack the silicate. We shall shortly return to the consideration of the chemical action of the sea-water; at present it would draw us away too much from those chemical phenomena which we are anxious to describe as clearly as possible.

The theoretical conclusions to be drawn from the composition of a hydrau-

(*b*) Smeaton arrived at the same practical conclusion from some of the synthetical experiments he made upon the composition of water cements, recorded at pages 117 and 118 of his "Narrative of the Building of the Eddystone Lighthouse;" and it must be a matter of surprise that the observations of so great an authority should have remained hitherto comparatively unknown, or that the valuable properties of the roasted ironstone should have been forgotten, until the able French engineers, whose essay I have endeavoured to translate, again called attention to them. Smeaton's own words are the following:—

215. "Upon the subject of a succedaneum for tarras or puzzolana, I have not seen anything similar in appearance to tarras but what has been of the calcareous kind; but, as the puzzolana was found to contain some iron, and I had seen masses of gravel strongly cemented (as it appeared to me) with nothing but pieces of malleable iron turned to rust, I had better expectations of success from the iron tribe. I therefore tried the scales that fall from the iron at a smith's anvil, which have long been known to be an excellent ingredient in making calcareous cement, and particularly where exposed to weather, or where water is concerned, and which, being well powdered, and mixed with lime in the same proportion, and treated in the same manner as puzzolana, I found (so far as I could observe) to produce an equal effect. A peck of smith's forge-scales is easily collected occasionally to do a small job, but to procure four or five tons would be far more expensive than to bring so much puzzolana from Italy. With a view, therefore, to works requiring large quantities, I tried iron ore after it had passed the fire and undergone what is commonly called calcination. This being powdered, I found it had a very good effect in water mortar, in causing it to set speedily, in preventing cracks, and, finally, in hardening it. On this account it was used in the Calder navigation, for the inside mortar of the best work, and for the face-work of the subordinate parts; but its strength in hardening lime was far inferior to that of puzzolana or of forge-scales. What I used was the siftings of the ironstone after calcination at the iron furnaces, which, being deemed too small and light to go into the furnace, was thereby better adapted to my use. I found that at the iron-works it had been frequently made use of to mix with lime in making mortar for the construction and repair of the water-building part of their own works; and the parts so sifted not being too large for the joints of their masonry, and having it in plenty at hand, they used it as it was; but, after a land-carriage of several miles, when brought to us, we ground it on a mill, to open its qualities and make it more effectual as well as go farther. This material, among the furnace men in these parts, is called minion. Minion is supposed by Mr. Michell to be what chiefly falls from the outside of the lumps of ironstone, and therefore containing more clay.

"Minion, or ironstone, burnt where it can be had in plenty, is a good succedaneum for puzzolana and tarras; and, if it is made up with lias or other proper water-lime, in equal quantities, will make a mortar more firm and hard than common lime made up with a common quantity of tarras or puzzolana; and hence we may be said to have materials within ourselves to serve the general purposes of water-works, but not so perfectly and completely as by the use of either of the foreign materials above specified.

"Wherever I have met with a reddish or a brownish stone, I have generally made trial of it, but never yet found anything to answer so well as forge-scales; except once, that I picked up a kind of coarse deep brown sandstone, somewhat of a tender nature, which, having burnt, powdered, sifted, and mixed with slack-lime, I made into a ball, and it proved of equal firmness with forge-scales; but, as it was a fragment found upon the surface of the earth, intermixed with others of different colour and kind, without the appearance of my being able to procure a quantity of it, I saw no probable use likely to result from this discovery further than that of the reason for which I mention it, which is that of demonstrating the existence in nature of the material we want in this kingdom, if we could but tell where to find a quarry or sufficient stratum of it—in which, though I have not succeeded myself, yet others may find a quantity either of this or something equivalent to it."—G. R. B.

lic lime containing no alumina are as follow:—It is indispensable that at the moment of immersion the proportion of free lime should be neither too great nor too small; it should not exceed the limit defined by practical experience as necessary for the slacking. We may add, that the setting by hydration of the silicate of lime, formed in the dry way, cannot properly take effect when the different parts of the limestone have been exposed to varying degrees of heat during the calcination: in other words, it is inadvisable to burn the limestone in pieces of too great magnitude; and the calcination should be continued long enough to allow the heat to penetrate the substance of the fragments in an equal degree.

It now remains for us to determine the solidity which may be acquired by the hydrosilicate of lime, and the precautions required to be adopted to ensure the setting under the various circumstances of different constructions, so as to obviate the porosity of the mortar. We shall discuss these practical questions in the second part of our notice.

Case 2.—We will now take a limestone containing pure clay, in intimate mixture, in the proportion of 15 to 20 per cent., which leaves a considerable excess of lime, compared with the silica and the alumina; and we will point out the theoretical actions which should take place during the calcination, during the preparation of the mortar with this hydraulic lime and quartzose sand, and after its immersion. We will examine afterwards the different results given by a larger proportion of clay, and a mixture of a less homogeneous character.

By protracted calcination, the carbonic acid is almost completely driven off, and the lime enters into combination with the silica and alumina. The sand, which is always mixed up with the clay in a certain proportion, evidently produces only a silicate of lime; but it is not so easy to distinguish the chemical nature of the compound resulting from the action of the excess of lime on the silicate of alumina. The energy of the acid of the silica becomes stronger with the increase of temperature, whilst alumina does not possess the same property. In the dry process, silica is an acid only in the presence of a large excess of base, and its action as an acid appears to diminish with the increase of temperature: consequently, in the particular case under consideration, the ingredients being intimately mixed and the lime in considerable excess, silicate and aluminate of lime will be produced, if the temperature be properly managed. If the calcination be urged on too far, it might render the silicate of lime more impervious to the action of the the water, or even effect the combination of the silicate and aluminate in a single compound, in which silica would be the only acid.

This difference in the products formed under various temperatures is proved by the properties possessed by the hydraulic limes, according to the mode of calcination and the description of fuel employed.

In cases where a large proportion of clay exists, the products of calcination may be very different. The excess of lime being very small, we should obtain the two compounds, silicate and aluminate of lime, only under the conditions of a very intimate union of the materials, and a carefully conducted calcination. If, on the contrary, the temperature be slightly raised, a large proportion of silicate of alumina and of lime would be formed, on account of the greater energy required by the silicic acid.

We have supposed the mixture of the clay with the limestone to be tolerably homogeneous, but in fact it is scarcely ever so. We may safely say its heterogeneity is always evident. From this would follow—1. That in limestones containing a small proportion of clay, portions would be found which did not contain an excess of lime; and, 2. That in very argillaceous clays, portions might be found in which the clay predominated. Consequently, the former would always contain, after a severe calcination, a certain proportion of silicate of alumina and of lime; and the latter, under the same conditions, would still contain silicate and aluminate of lime.

These considerations lead us to the conclusion that the chemical composition of hydraulic lines and cements produced from argillaceous limestones, and, consequently, their mode of action in contact with water, depend on, first, the proportion of clay, and the degree of intimacy in which it is combined with the limestone; and, secondly, the duration and temperature of the calcination. The effect of this last is greater when the limestone is burnt in large fragments, because in that case the different parts are not exposed to the same temperature, and, therefore, are not equally in a state to participate in the action produced by water.

In an exclusively theoretical point of view, a slow calcination, at a temperature merely sufficient to drive off nearly the whole of the carbonic acid from the limestone, gives the following results:—

A. For the slightly argillaceous limestones, free lime, silicate of lime, aluminate of lime, and perhaps a small quantity of the undecomposed carbonate. The silicate of alumina and lime can only be present in very small quantity, and that only in consequence of an unequal distribution of the clay.

B. For the highly argillaceous limestones, silicate of lime, aluminate of lime, a small proportion of free lime, silicate of alumina and lime, always in considerable quantity, and alumina in a nearly inactive state.

The principal difference between these two products results from the proportion of free lime—very large in the former instance, and very small in the latter—rather than from any difference in the chemical nature of the compounds formed. This difference can only exist in the greater or less proportion of silicate of alumina and lime, which can never be very large in a calcination conducted at a low temperature. Consequently, an argillaceous hydraulic limestone might yield a product closely resembling those of argillaceous cement stones, on condition that the calcination be so conducted as to leave a considerable proportion of lime in combination with the carbonic acid.

Calcination, when urged to a high degree, even as far as the partial agglomeration of the materials, would yield the following products:—

A. For the slightly argillaceous limestones, an excess of caustic lime, silicate of lime, aluminate of lime, and a considerable proportion of silicate of alumina and lime.

B. For limestones containing a great quantity of clay, a rather small proportion of silicate of lime, and aluminate of lime, and principally silicate of alumina and lime. The free lime is always in very small quantity.

There is, then, a great difference in the chemical composition of the two kinds of products obtained by calcination at a high temperature—that is to say, hydraulic limes and cements. The cements contain a large quantity of alumina in combination with the silica, while the hydraulic limes contain but very little. Consequently, we should not succeed in assimilating them to highly burnt cements by artificially saturating with carbonic acid the excess of free lime contained in them. Thus theory verifies, in a very simple manner, the facts observed in practice, that hydraulic limes can be made to resemble very closely cements manufactured at a moderate temperature, when the excess of lime is saturated with carbonic acid; while the same assimilation cannot take place in the case of cements produced at an elevated temperature. To what has been already said we should add that the limestones are generally burnt in tolerably large lumps; and, in the case of artificial mixtures, the calcination is performed on bricks. Considerable variations are thus produced in the temperature to which the several parts are exposed, and, consequently, differences arise in the state of combination, or, at any rate, of aggregation. In contact with water, these would give rise to different degrees of rapidity in the setting.

It is, moreover, very important to consider in detail what may be the action of water on these different products, leaving aside for the present the action of the salts contained in sea-water.

Let us take, in the first place, a hydraulic lime obtained at a moderate temperature, containing an excess of free lime, and silicate and aluminate of lime, but only a small proportion of alumina in combination with the silica and the lime.

The water dissolves at first a portion of the lime, while the carbonic acid in solution enters into combination with a certain proportion of the base. The silicate and aluminate become hydrated, and set more or less gradually as the different parts have been more or less uniformly burned. The setting is produced by a species of crystallization, which comprehends the carbonate of lime together with a small portion of the hydrated lime; the contraction caused by the setting expels another portion of the hydrated lime, which forms a white cloud around the material. This fact is principally observable in the experiments conducted in the tubs. The silicate of alumina and lime, in small quantity, would be rapidly decomposed, owing to the excess of lime, and produde silicate and aluminate of lime, which would become hydrated as fast as formed.

The precautions necessary to be adopted in practice, refer to two different actions: firstly, it is necessary that the setting should be tolerably uniform and contemporaneous for the silicate and aluminate, and for the differently-prepared portions of these two compounds. This first point is attained easily enough in the case of lightly-burned and slow-setting hydraulic limes. Secondly, it is necessary that the mortar should not contain too large an excess of free lime. In order to understand the importance of this, we must examine the chemical actions which might operate on this free lime. Water containing carbonic acid would gradually produce carbonate of lime, whose formation proceeds, by slow degrees, from the surface to the centre. This salt is calculated to act a very useful part by reason of its insolubility; for it forms on the surface an impermeable coating, which prevents water from passing too easily into the interior; and, consequently, it tends greatly to retard the destructive chemical action not only of the water itself, but still more so that of the salts contained in sea-water. Experience shows that, under the ordinary conditions of the employment of hydraulic limes, mortars are porous; and that the carbonate of lime formed on the surface is not always sufficient to prevent the penetration of water into the interior. Practical men must, therefore, consider the best methods of preparing mortars, which should be sufficiently dense to resist this passage. We are of opinion, from some experiments made at Hâvre, that the solution of this difficult problem may be arrived at. In the meantime, it would be desirable to investigate the action of water on hydraulic mortars which are more or less permeable.

This action itself is of necessity complicated and progressive. The water gradually dissolves the lime not saturated with carbonic acid, and thus, consequently, renders the mortar still more porous and permeable. As soon as the greater portion of the free lime is carried off, the action of the water is directed to the aluminate, and afterwards to the silicate; and it tends to carry off their lime, and, consequently, to destroy the cohesion previously acquired. To this action of the water by itself is superadded the tolerably energetic action of gases and salts of magnesia contained in the sea-water, which action we will shortly consider. For this reason, it seems impossible to prevent the decomposition of hydraulic mortars, so long as we are unable to guard against the ready penetration of water. In hydraulic limes, containing a large proportion of alumina, the disintegration would be more rapid, because the aluminate is more readily attacked than the silicate, and because the decomposition of the aluminate, although insufficient to produce the disintegration of the mortar, yet, by rendering it more permeable, assists the chemical action on the silicate. Consequently, hydraulic limes containing no alumina would produce mortars of much greater durability than those derived from the aluminous limestones.

In either case, an indefinite degree of resistance can only be attained by attentively considering the processes of preparation, and the modes of working, which should avoid the porosity of the mortars. The same object is gained where the works are covered with a natural coating, such as carbonate of lime, shells, sea-weed, mud, &c. From this it appears that we must not deduce the good qualities of the materials employed from the great durability of certain mortars. It might happen that the same materials would not resist as well in situations where the protecting coat did not so rapidly spread itself over them.

We will consider, in the second place, the highly burnt hydraulic limes which contain a certain proportion of the silicate of alumina and lime.

The action of the water and carbonic acid on the free lime is the same as in the former case; the silica and alumina being more highly, and, generally speaking, also more unequally burned, combine more slowly with the water, and present greater irregularities in the setting; the silicate of alumina and lime, on the contrary, being pretty easily decomposed by the excess of lime, produce silicate and aluminate of lime, the hydration and setting of which, are, comparatively speaking, very rapid. It is, therefore, an extremely difficult matter to regulate all these different actions, and to obtain a proper uniform setting. The only practical method we can suggest, "*d priori*," is that which we have already described for the puzzuolano mortars; viz., a prolonged slacking with a quantity of water insufficient to produce setting, but enough to moisten the ingredients, and allow the chemical action to be set in motion. This slacking would require in practice a considerable degree of experience to determine the most suitable quantity of water. It possesses the advantage of allowing the carbonic acid of the atmosphere to saturate a portion of the free lime, and so to replace the lime which is soluble (and therefore, on account of its great excess, injurious) by an insoluble but inactive substance. As the carbonic acid is absorbed more easily in proportion as the free lime is in greater excess, there will certainly be no reason to fear that the whole of the lime would not pass into the form of carbonate.

We have, however, another series of practical experiments to suggest. Hydraulic mortar, after setting, should be pulverized, moulded into bricks, and exposed to a second burning. By adopting a temperature just sufficient to drive off the water from the silicate and aluminate of lime, we should obtain a very homogeneous material, whose combinations would only require to be hydrated in order to effect the setting. It is certain that this mode of preparation by double burning, coupled with the precautions necessary to prevent porosity, would produce excellent mortar. We have only to consider whether it would be sufficiently economical in application, or whether it could be replaced by the employment of materials somewhat different, but properly selected.

Case 3.—The third case we have to consider is that of cement, produced by a moderate degree of burning. It contains silicate and aluminate of lime, a greater or less proportion of silicate of alumina and lime, and a small quantity of caustic lime. The water acts almost instantly on all these com-

pounds, and experience shows us that the setting takes place very rapidly; the hydration must be succeeded by a decomposition arising from the action of the very small excess of lime on the silicate of alumina and lime. This transformation into silicate and aluminate of lime, both of which substances would assist the durability of the cement, might lead to its disintegration if effected too slowly—that is to say, if the temperature of the calcination were greater in some parts than in others. The most highly burnt portions are those which contain the largest proportions of silicate of alumina and lime; and, as the action of the very small excess of lime, when in contact with water, is of necessity very gradual on this highly burnt silicate, it is possible that the solidity at first acquired by the more lightly burnt portions would be progressively destroyed by the changes produced in the more highly burned portions. The burning of cements at a moderate temperature is, consequently, an operation of great delicacy, as it is almost certain that the quality of the product would be inferior, if the heat were not very uniformly distributed.

Those cements whose rapid setting has been properly effected should be only slightly porous or else protected, as in the case of the hydraulic mortars, by foreign substances, which would oppose the too ready penetration of the water. In fact, the carbonic acid contained in the water can only form a very small proportion of carbonate of lime by its combination with the free lime; and, in the case of a material allowing too easily the passage of water, that water and the salts it contains act firstly on the aluminate and afterwards on the silicate; and thus necessarily produce the decomposition of the cement. Water, of itself, acts very gradually, and would merely produce disintegration; sea-water exercises a much more rapid action on the contained salts, one which may produce disintegration and swelling.

The employment of cement in marine constructions cannot be attended with satisfactory results, unless the precautions necessary to avoid porosity be attended to. For all these reasons, the success of moderately burned cements depends quite as much upon practical experience and the indispensable care in the burning and in the working as upon their chemical composition.

Means have frequently been sought of modifying the mode of application of the quick-setting cements, by mixing them with a certain proportion of rich lime. The effect produced might be beneficial, if the mixture, after being moistened with a small quantity of water, were left to work for a length of time sufficient to develop all the chemical actions. The material, placed in contact with water, would be nothing more than a mixture of caustic lime and of silicate and aluminate of lime, and might possess the power of setting with great hardness.

We have now to consider, in the last place, the cements exposed to such a high degree of calcination as to cause those parts to run which are most exposed to the action of the fire. They contain a very large proportion of silicate of alumina and lime, which are in very close combination, and are imperfectly pulverized; silicate and aluminate of lime; and a very small quantity of free lime.

Immersion does not generally produce immediate setting: it takes place after an interval of some hours, and frequently of several days. The slowness of the setting would result from the fact, that the silicate and aluminate of lime are incapable of rapid hydration, in consequence of the high degree to which they have been burned.

The double silicate of alumina and lime may, then, in most cases, be in a great measure transformed into the silicate and aluminate of lime by the action of the very small excess of lime, or even by the water itself. The setting may be very perfect, except in the case of the somewhat large grains of agglomerated silicate, which would at first remain inactive. They would yield but very slowly to the affinities of the humid action, which tend to separate the silicate from the aluminate of lime; and, if in small proportion, this action would not produce disintegration. The great distinction between the moderately burnt, quick-setting cements, and the highly burnt, but comparatively slow-setting ones, thus consists in the transformation of the double silicate of alumina and lime, which, in the latter description of cements, takes place to a great extent before the setting, while, in the former instance, it only occurs afterwards.

In other respects, both as regards the highly burnt and the moderately burnt cements, the subsequent action of the water and of its contained salts is nearly the same: we cannot hope for durability unless we succeed in preventing the too frequent renewal of the water in the inner substance of the cement. This object might be attained by the necessary practical precautions against porosity, or by arranging the construction in such a manner that the cement would be at once protected by an almost impervious covering.

Experience shows that the quick-setting cements, although they present in most cases disadvantages in sub-aqueous constructions, resist perfectly well in the open air; and even under this, the most favourable condition, they require to be applied by particularly skilful workmen.

In the foregoing observations we have assumed that the argillaceous limestones were entirely free from those substances which most generally accompany them in greater or less proportion, viz., coarse-grained sand, magnesia, and oxide of iron. It is, however, necessary to examine the part which these bodies would take in the burning, and during the preparation of mortars and cements.

It is easy to perceive the effect of the coarse quartzose sand: during the calcination it is partially attacked by the lime, and transformed into silicate of lime, which afterwards assists in the setting. The unaffected portion remains inactive, and acts in the same manner as the sand which is afterwards added to mortars and cements. The sand resists contraction, and imparts, perhaps, a greater power of resistance to crushing. In contrast to these advantages we must place a very serious inconvenience, that of contributing in a great measure to render mortars and cements very porous, and consequently permeable to water; which is, as we have shown, an almost certain source of decomposition.

We think it advisable, therefore, to state, as a problem of the highest importance, the practical precautions which would allow of the employment of a small quantity of sand, and at the same time obviate almost entirely the contraction at the moment of setting. We are not, however, considering the use of sand in an economical point of view; because, in marine constructions, true economy does not consist in making mortars and cements whose cost per cubic yard shall be but small; but in obtaining, even at an increased expense, materials of great solidity and indefinite durability.

Magnesia is only rarely found in limestone, and generally in very small quantity. We may admit as exceptions some calcareous beds, now actually worked for hydraulic lime and cements, which contain from 10 to 12 per cent. of magnesia. In the various operations magnesia acts nearly in the same manner as lime: we must, however, point out some remarkable differences in the chemical properties of these two bases. Magnesia is, in general, a less energetic base, but it possesses at least as great an affinity as lime for alumina. Its compounds with silica and alumina are susceptible of hydration, and yield insoluble products, which resist much better than the corresponding hydrates of lime the action of water, and of the carbonic acids and salts contained in sea-water.

These properties would lead us to imagine that mortars or cements in which magnesia supplied the place of lime might be made to set under water, and afterwards resist with greater force the chemical action of the sea-water. This fact is, moreover, well established by the recent experiments of M. Vicat. Unfortunately, magnesia is not found in nature in sufficient abundance to admit of its employment in constructions, to the exclusion of lime.

The limestones which contain magnesia yield products which are generally more difficult to employ than those derived from the pure limestones. They contain, in fact, different silicates and aluminates; the one having lime for their base, the other magnesia. These last, in the presence of free lime, would or might be partially decomposed after immersion; and consequently, from the complicated nature of the action, it would be more difficult to obtain a decided and durable result. It is principally in cases where magnesia is present in considerable quantities that a preliminary slacking with a small quantity of water is indispensable for the complete development of all those actions which might impede the setting, or subsequently produce the disintegration of the mortar.

The oxide of iron is found in small quantities in almost all limestones, and may generally be considered as inactive in the calcination and the setting. In fact, as the lime is in great excess in hydraulic limestones, the oxide of iron cannot combine with the silica; the temperature of the calcination is sufficient to destroy its hydration, and in this particular form of calcined oxide it has no tendency to combine with lime in the humid way.

In cement stones exposed to prolonged calcination, the oxide of iron may act somewhat differently. It enters partially into combination with the silica and alumina in those portions which begin to assume a vitrified form. It enters into this compound in the form of protoxide; at a later period, after the decomposition of the compound silicate by the lime, or by the water alone, the protoxide passes into a peroxide, which, being formed in the humid way, may enter into combination with the lime. This compound is susceptible of hydration, and is insoluble in water; but it is decomposed still more readily than the aluminate of lime by water, carbonic acid, and the salts of sea-water. It cannot, therefore, be considered durable, still less as possessing any useful influence on the strength of the mortar.

There was, indeed, no need of recounting the chemical properties of the oxide of iron, in order to arrive at this conclusion. The oxide is almost always present in limestone in small quantities; and, from the number of hydraulic limes and cements acknowledged to be of good quality, we might adduce as many examples of the absence as of the presence of oxide of iron. We may in general consider it as inactive, and conclude, only after an examination of all the circumstances of the calcination and application, that it might, in a partial degree, form an indifferently durable combination with the lime.

We have before mentioned that the bituminous argillaceous limestones very frequently contain iron pyrites, dispersed in very fine grains, and that their calcination causes the production of a considerable quantity of sulphate of lime; in some few cases this substance is found ready formed in the calcareous beds. Engineers are almost unanimous in rejecting the employment of hydraulic limes and cements containing too large a proportion of sulphate of lime; but no limit has been prescribed.

The properties of the sulphate of lime sufficiently account for its injurious influence. It is very slightly, and moreover very slowly, soluble in water, after being strongly calcined; consequently, nearly the entire quantity remains in the mortar or the cement for a considerable time after immersion. By its gradual combination with the water it produces plaster, which does not generally set at the same time with the silicate and aluminate of lime. The crystallization of the plaster, being accompanied by an increase in volume, necessarily causes the mortar or cement to break up, when it occurs after the normal setting, and more particularly when the sulphate of lime is not uniformly distributed, but found in larger quantities in some places than in others.

For the slow-setting mortars, we cannot determine whether the crystallization of the plaster would take place before or after the setting of the hydraulic compounds; but, as regards the more rapidly setting cements, we may be certain that it would be subsequent to the hydration of the compounds of lime with silica and alumina.

It is, therefore, in cements especially that we must regard the presence of sulphate of lime as very detrimental. We are of opinion, too, that the effects produced would be the same both in fresh and sea-water; and that, in consequence, it is advisable to exclude from hydraulic works those cements which contain sulphate of lime in any notable proportion.

In hydraulic mortars containing sulphate of lime it may happen that that salt would become crystallized simultaneously, or nearly so, with the hydration of the compounds of lime with silica and alumina. Under these, the most favourable conditions, which it is impossible to foresee, the plaster would still be very injurious from its solubility in water, which is, however, not very great. It is carried off gradually by the water, and thus contributes to increase the porosity of the mortar, the inevitable consequence of which is its disintegration at the end of a greater or less period. The presence of sulphate of lime in any considerable quantity is, therefore, very prejudicial; and the hydraulic limes and cements containing it do not generally allow of the construction of solid or durable buildings.

The presence of phosphate of lime in limestone is, so to speak, an exceptional case; and, moreover, it can produce no injurious effect on the setting and durability of mortars and cements. The phosphate, being basic and insoluble in water, does not crystallize, like the sulphate, with an increase in volume, and may therefore be regarded as an inactive substance, both during and subsequently to the setting.

§ 4. *Action of the Salts and Gases contained in Sea-water.*

In the preceding observations we have reserved the consideration of the special action of the salts contained in sea-water—an action certainly very energetic, and to which may be attributed the greater portion of those accidents which have occurred in our ports.

It is now generally admitted that mortars and cements are not affected in equal degrees or in the same manner by fresh water and by sea-water, and that materials which stand well in the former are decomposed in the latter, after a greater or less interval, if especial care be not observed in their preparation and manipulation. The study of the chemical action of the salts contained in sea-water is far from being complete, and requires a long course of experiments: at present we must confine ourselves to the theoretical examination of the more important facts.

The difference of the action of the sea-water and that of fresh water is shown during two particular periods: the first comprises the time elapsed between the slacking and the setting; the second is subsequent to the solidification of mortars and cements. We will consider these two periods separately, taking as our examples the two most strongly characterized materials—viz., mortar made of sand and hydraulic lime, containing an excess

of lime; and cement mixed with sand, and not containing any considerable proportion of free lime.

First Period.—The setting of mortars and cements is generally much more gradual in sea-water than in fresh; and this is more especially the case with mortars than with cements. These facts can only be explained by the presence of the salts contained in sea-water; and the only salt which can exercise any remarkable action is the chloride of sodium, which alone is found in sea-water in considerable quantities.

Sea-salt may retard the setting in two ways: in the one case, by interposing itself between the atoms of the water and those of the compounds to be hydrated; in the other, and with greater probability, it opposes its affinity for water to that of the silicates and aluminates, and thereby retards the completion of the hydration.

It is not easy to explain the retardation of the setting in sea-water; but it is important that our theoretical investigations should be carried still further, and that the chemical actions which precede the setting, and which may vary in fresh and in sea-water, should be clearly defined.

Sea-water contains in solution soda, magnesia, lime, sulphuric and hydrochloric acids, free carbonic acid in very variable quantities, and occasionally sulphuretted hydrogen.

The salts of soda and magnesia may, perhaps, exercise some chemical action on the free lime, but it is certainly very small as regards the salts of soda, on account of the strength of the base, which is not readily displaced by the lime; and also as regards the salts of magnesia, which are, on the contrary, easily decomposed by lime, on account of the small proportion of magnesia contained in sea-water. The salts of lime are evidently inactive.

Up to this point, then, as regards the solid salts dissolved in sea-water, the chemical action during the period which precedes the setting cannot be regarded as very important. The sea-salt causes a retardation in the setting, and that is its principal action.

It is not so with the carbonic acid. It is absorbed with great rapidity by the caustic lime, and might, in case of too gradual setting, carry off a certain quantity of lime from the silica and alumina. It exercises, therefore, a very great influence on the portion of free lime which remains in the mortar or in the cement after its solidification, and might in some cases transform the whole of the caustic lime into the carbonate, and so impair the stability of the setting, by partially decomposing the active combinations of the lime.

It would, therefore, be a matter of great importance to determine the quantity of carbonic acid which might be found in sea-ports under every contingency that might be presented. These experiments should be conducted on the spot, and would lead to very interesting results, by comparing, in each particular instance, the proportion of carbonic acid dissolved in the sea-water with that ascertained in other localities in which hydraulic materials, of analogous character to those under consideration, have given favourable results. It might be possible to determine beforehand, and almost with certainty, the proportion of free lime that should be left in hydraulic materials at the time of their application.

Sulphuretted hydrogen would produce an action analogous to that of the carbonic acid, but it might be rendered more complicated by the presence of air. It might produce sulphuretted oxide of calcium nearly insoluble, or soluble compounds of lime with an oxygenated acid of sulphur. In both cases the result would be a partial saturation of the free lime. It appears certain that sulphuretted hydrogen only exists in appreciable quantity in exceptional situations; but, where it does present itself, it is indispensably necessary to take notice of it, in order to determine the proper proportion of free lime to be introduced into the mortars and cements.

Thus, in the first period, or that which precedes the setting, the sea-salt would act by retarding the hydration; the salts of magnesia, the sulphuretted hydrogen, and, above all, the carbonic acid, produce chemical actions which take effect at first on the free lime, and greatly influence the excess of lime remaining at the moment of setting. These actions are superadded to the dissolving action of the water, which would be nearly the same in sea-water or in fresh water.

From this we perceive, that if it be desired to employ in sea-water materials which set slowly, and which only contain a small excess of lime, the setting will be difficult and even incomplete, especially in situations where the sea-water holds in solution a considerable proportion of carbonic acid and sulphuretted hydrogen. In other words, it is important that the selection of the hydraulic materials should be guided by the quantity of carbonic acid and sulphuretted hydrogen contained by the sea-water under normal conditions.

Second Period.—In order to study the chemical action of the salts of the sea-water on hydraulic materials after setting, we will first examine a mortar composed of hydraulic lime and sand, and containing a tolerable excess of lime at the moment of immersion.

The solidified mortar, which is necessarily somewhat porous, contains—

1. The hydrated silicate and aluminate of lime, which, by contracting more or less, have produced the setting; and,

2. Sand, in very large proportions.

3. Carbonate of lime, formed by the carbonic acid of the atmosphere and of the sea-water, previous to setting, and which is consequently an inactive substance.

4. Hydrated lime, remaining undissolved and unchanged by the actions of the former period.

This lime is partly driven out and partly carried towards the surface by the contraction which accompanies the setting; and this is a phenomenon which might be made extremely useful, if we could succeed in properly limiting the contraction and avoiding too great porosity. In fact, the lime which is hydrated on or near the surface would be the first to combine with the carbonic acid of the sea-water. This combination would produce no swelling, and would tend to close up the outer pores by filling them with an insoluble material.

The practical experiments required to be made for the various hydraulic limes, and in each particular situation, should be especially directed to the determination of the proportions of sand and of free limes and the mode of preparation and of application which afford the most convenient scope for the actions before described. These experiments are delicate and complicated, but their importance is very evident, inasmuch as we may succeed in obtaining, by the aid of the remaining excess of hydrated lime, and the frequently rapid action of the carbonic acid in the water, an almost impervious covering, which would prevent the easy renewing of the sea-water in the inner substance of the mortar; and in this manner we may avoid almost entirely the ulterior action.

The experiments ought to be made on all the descriptions of lime which it may be desirable or possible to employ, and in each particular locality—firstly, because the rapidity of the setting and the force of the contraction, variable in different materials, may affect the proportion of hydrated lime remaining in excess at the moment of setting, and which may be carried towards the surface; and, secondly, because the proportion of carbonic acid varies in different localities. Experiments in tubs cannot be conclusive, because we cannot reproduce in such cases the agitation and the movements of the open sea, which certainly exercise great influence over all chemical and mechanical actions, both before and after the setting. It is absolutely necessary that the experiments should be made in the open sea, and under circumstances resembling, as closely as possible, the actual conditions under which the mortar would be employed.

We will now proceed to examine the chemical actions which follow after the setting in the two following cases:—

1. Where the mortar is not rendered sufficiently impermeable by the carbonate of lime produced.

2. Where the hydrated lime is in too great excess, as compared with the carbonic acid contained in the sea-water.

CASE 1.—The sea-water, being renewed more or less readily in the inner substance of the mortar, would act on the lime remaining in the free state, and would gradually dissolve it, either under the form of the hydrate or of the salts of lime, depositing a small quantity of magnesia, which would probably remain in the form of powder, and would therefore in no way assist the solidity of the construction.

This first action, which is more or less gradual, would render the mortar more and more porous, and consequently become more and more energetic. If the construction, therefore, be not protected by a coating of shells, by the accumulation of sea-weed, or by mud, &c., the chemical action of the water and the salts of magnesia, after having exhausted nearly the whole of the free lime, would be directed to the silicate and the aluminate of lime. The water alone would tend to carry off the lime by degrees, first from the aluminate and afterwards from the silicate; and, after the lapse of a considerable interval, would thus produce the disintegration of the mortar.

(*To be continued.*)

Price Current.

CASTINGS, per Ton.

Average Weight of Cast-Iron Gas-Pipes, per Yard.

1¼ in.	2 in.	2½ in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	12 in.
16	21	28	33	51	70	89	107	126	149	177	208 lbs.

Retail Prices are 5 to 10 per cent. higher.	London.	Glasgow	Newcastle.	Wales.	Yorkshire, Derbyshire, and Staffordshire.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Pig Iron, No. 1	4 10 0	3 10 6	3 13 0	4 0 0	4 10 0
1½ and 2 inches Socket Pipes	8 0 0	7 5 0	7 10 0	7 15 0	7 10 0
2½ and 3 „ „ „	7 10 0	7 0 0	7 5 0	7 10 0	7 5 0
4 and 5 „ „ „	7 10 0	6 15 0	7 0 0	7 5 0	7 0 0
6 in. & upwards „ „	7 5 0	6 10 0	6 10 0	7 0 0	6 10 0
Retorts, 1st fusion, hot blast	7 0 0	...	7 0 0	7 5 0	7 0 0
„ 2nd „ cold „	8 0 0	...	7 5 0	7 10 0	7 5 0
Tank Plates, ⅜ thick and above	7 10 0	6 15 0	7 0 0	7 5 0	7 0 0

COALS.

NEWCASTLE.	s.	d.		SCOTCH CANNEL.	per ton.
Unscreened.				Boghead, at Leith	32s. 0d.
Whitwell Primrose	6	3	per ton	Kirkness, best	23 0
Pelton, Medomsley, & Burnhope	6	6	„	Capeldrae, 1st quality	20 0
Pelaw	6	9	„	„ 2nd „	12 6
Eighton Moor, New Pelton, Pearth, South Pelaw, Washington Hutton, & South Pearth	7	0	„	Lesmahago, at Glasgow	25 0
				„ „ Leith	27 6
				Arniston	22 0
				Wemyss	20 0
				Knightswood	18 0
Ramsay's Newcastle Cannel	16	0	„	Pirnie	15 0

SUNDRIES.

Best Newcastle fire-bricks . 60s. per 1000	Welch bar iron, in London £8. 10s. per ton
„ „ „ clay . . 12s. per ton.	Foreign spelter . . . . £30. 15s. „
Cliff's fire-bricks at Wortley, 57s. 6d. p. 1000	English block tin . . . . . £140 „
Tough cake copper . . £121. 10s. per ton.	Banca „ „ . . . . . £144 „
English pig lead . . . . . £24. 10s. „	Tarred rope yarn . . . . . 26s. per cwt.

WROUGHT-IRON TUBING, subject to 40 per cent. Discount.

	2 inches.		1½ inch.		1¼ inch.		1 inch.		¾ inch.		½ inch.	
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
Patent welded tubes, from 2 to 12 feet, per foot	1	8	1	0	0	10	0	7	0	5	0	4½
„ „ „ 6 in. to 18 in., each	3	0	2	0	1	9	1	3	1	0	0	9
Connecting pieces, or long screws	3	6	2	3	2	0	1	6	1	2	0	11
Bends, springs, and elbows—wrought iron	3	9	2	3	1	9	1	0	0	10	0	8
Tees, wrought or cast	4	0	2	6	2	0	1	6	1	1	0	10
Crosses, wrought or cast	4	6	3	0	2	6	2	0	1	6	1	2
Iron cocks	17	6	9	6	7	6	4	6	3	3	2	6
„ with brass plug	28	0	16	0	13	0	7	0	5	6	4	6
Diminishing sockets, caps, plugs, and nipples	1	3	0	9	0	8	0	6	0	5	0	4
Plain Sockets	1	0	0	8	0	7	0	5	0	4	0	3
Syphons, 2 quart	15	0	14	0	13	6	13	0	12	0		

FREIGHTS, per Ton.

Coastwise—Newcastle.		*Foreign.*	
Chatham & Roches-	6s. 9d	Boulogne	8s. 9d
Cork [ter	10 6	Barcelona	26 0
Dover	7 0	Bordeaux	15 6
Dublin	11 3	Cadiz	16 0
Exeter Quay	9 6	Calais	8 9
Folkestone	7 3	Dieppe	9 6
Hastings	8 0	Genoa	25 0
London [mouth	6 9	Hamburg	9 3
Lowestoft & Yar-	5 0	Havre	10 9
Lynn	5 6	Leghorn	24 0
Portsmouth	8 6	Lisbon	18 0
Plymouth	9 3	Rotterdam	8 0
Whitstable	7 3	Stettin	12 6
Weymouth	8 6	Trieste & Venice	27s. to 28s.

A Novel Dining Room.—The directors of the Western Gas Company and their friends, to the number of twelve individuals, inaugurated the completion of their new chimneys on the 14th instant, by a dinner, cooked on the premises, and served on the top of the shaft, where a platform was erected, from which the guests could enjoy the magnificent prospect spread out at their feet, extending to the Surrey Hills and the Grand Stand on Epsom Downs on one side, and to Harrow on the other. A round table provided ample accommodation for all, and the conviviality was kept up till the setting sun gave notice that it was time to descend.

Collapse of a French Gas Bubble.—The shares of the company called the "*Union des Gaz*," which, two years' since, were quoted on the Paris Bourse and found *bonâ fide* purchasers at 80 per cent. premium, have been recently sold at 78 per cent. discount. The company has entered into engagements at Toulouse, Strasburg, Nimes, Genoa, and other towns in France and Italy, and incurred obligations to the extent of £256,000 beyond its means of liquidation. The shareholders were convoked by the provisional *gérants* on the 15th instant to receive an intimation that their attempts had failed to issue a sufficient sum of 6 per cent. mortgage bonds at 8 per cent. discount, redeemable at par in 25 years. Doubts are entertained whether the profits will suffice to pay the interest and sinking fund, and hence the indisposition of capitalists to take up the bonds.

Travelling by Gaslight.—We understand that the directors of the Great Southern and Western Railway Company, with that enterprise and desire to contribute to the comfort of persons travelling by their line which have ever characterized their management, are about to add another instance to the many they have already given of their determination to make the Great Southern and Western Railway as perfect and as complete in its details as any line of railway in the kingdom. Arrangements are now being made, we understand, by which, by aid of the most recent scientific adaptations, the whole of the trains travelling at night will be lighted by brilliant gas.—*Freeman's Journal.*

Irish Turf Gas.—The Waterford papers recently contained a notice of a successful exhibition of turf gas during the meeting of the Waterford Royal Agricultural Society, which has called forth the following pungent letter from Mr. Anderson, one of the lessees of the Waterford Gas-Works, the assertions in which have not been contradicted :—

Sir,—In your impression of the 26th of August I observed an anonymous communication, headed—"Irish Turf Gas," which states that on Friday, the 21st of August, an exhibition of turf gas took place in the interior and exterior of the town hall; that the experiment was most successful; and that a company is already formed in London, with a capital of £100,000, for extending lighting by turf gas. I beg to state that, so far as my observations and inquiries enabled me to judge, the foregoing does not contain one single statement worthy of credit.

In the first place, the parties who were experimenting at the "rere of the town hall" did try to make gas from peat, on Thursday night, and failed; and, to keep up appearances, they surreptitiously connected their pipes to those of the gas company, and thus for some time the gas, even of the "brilliant star," was the ordinary coal gas supplied from my works.

I should say that this stealing of my gas was done in direct contradiction of my orders, that no mixing up of their gas with ours should on any account take place, though I would lend them any assistance—which I did—in the loan of pipes, &c. Second—That the gas which was burnt in the star in front of the town hall on Friday night, the 21st ult., was not "Irish peat gas," but Scotch Boghead cannel coal gas, the richest known coal in existence, and which cannot be delivered in Waterford under £2 per ton. And, third—That I have made inquiry at the Registration Office in London, with the prospectus of the "Carburetted Peat Gas Company for Ireland (Limited)" in my hand, but no such company has been registered there. I believe an attempt has lately been made to procure shareholders for such a company in Waterford, and statements have been circulated that gas from peat can be made much cheaper than from coal. These statements have yet to be verified; and, however much we may all wish to see the bogs of Ireland turned to profitable account, I would suggest to the people of Waterford to allow the scheme to be tried in some of the towns which, according to the prospectus, are already secured for carrying out the project.

I hope my having embarked several thousand pounds of money in the Waterford Gas-Works, where I am now investing more in extensive alterations, to meet the wishes of the gas-consuming public, will be considered by you a sufficient reason for my plucking the borrowed plumes from the back of your anonymous correspondent, and that you will allow me to take this opportunity of stating that the temporary suspension of the gaslight at the Agricultural Dinner was the result of the tampering to which I have alluded.—I am yours, &c.,

Gas-Works, Waterford, September 3, 1857. George Anderson.

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Mr. KERBY is prepared to design Apparatus for the Manufacture of Sulphate, Muriate, or Carbonate of Ammonia.

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References.

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Thirty years RETORT SETTER to some of the leading London and Provincial Gas Companies, to whom he can refer, begs leave to draw attention to his economical mode of Setting Clay or Iron Retorts, &c.

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Manufacturers of Station and Patent Protector Consumers' Meters, Patent Slide-Valves, Gas-Fittings, Pipes, &c.

Also, High-pressure Cocks, Hydrants, Closets, and all Water-Fitttings.

NOTICE.—Mr. N. DEFRIES, Consulting GAS ENGINEER, begs to inform gas companies and the public, that he is desirous of meeting any gentlemen at his WORKS, NEW ROAD, ST. PANCRAS, where, under his own superindence of the manufacturing department, they will have the fullest opportunity of investigating the many improvements he has recently effected in his ROTARY-VALVE DRY GAS-METER, by which full security will be afforded against leakage and non-registration, even against the searching effects of Cannel Coal Gas. The Rotary-Valve Meter is warranted to register inflexibly correct at a working pressure of half a tenth, and less than a quarter of a foot per hour upon a blue light; and a guarantee will be given to all gas companies to keep it in repair for not less than five years, free of expense. With this meter the gas-supplier may fully depend upon a fair return, and the public upon having a just measurer.

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Gas-works erected for private houses, where no gas company exists.

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Beg to draw the attention of the Engineers and Managers of Gas-works to the superior quality of their goods, and more especially to their BRICK RETORTS, which, in addition to the almost infusible nature of the Fire-Clay employed, have the great advantage, from its large excess of Silica, of expanding by the application of heat, and consequently becoming sounder and less liable to leak by use. Their cost is less than that of the ordinary Clay Retorts.

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Beg to draw the attention of Engineers and Managers of Gas Works to the superior quality of the Article they manufacture, both in respect of the iron employed, and the perfect manner in which it is welded; in proof of which they can refer to the testimonials of the most eminent Gas Engineers, and the experience of the principal of the large Gas Companies of the kingdom.
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GAS AND CONSULTING ENGINEER,

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which may be had, either combined with the Engine; combined with both Engine and Boiler, and Portable; or separate, by itself. Also, his

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one of which answers the purpose of THREE ordinary Valves, in connecting Purifiers, or in shutting off and passing a Station-Meter, or other apparatus. Also his

RETORT SETTINGS,
by which any number of Retorts, up to Twenty, can be heated by one Coke and one Tar Fire, reducing the fuel account in many instances to one-half of what it now is, and without the production of any smoke.
Mr. Anderson has been extensively engaged for the last ten years in the Construction and Management of Gas-Works, and all his improvements have been brought into successful operation under his own eye previous to being submitted to the public.
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are the most durable, and are cheaper and better than any other.
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Beg to announce that, in addition to the manufacture of GAS-METERS, they continue the manufacture of METERS for MEASURING WATER, SPIRITS, &c., commenced, under Patent in 1849, by the late Mr. William Parkinson.
These Meters are as simple and durable as the Gas-Meter, and as correct as that instrument in the registration of the fluids passing through them.

By Her Majesty's Royal Letters Patent.

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Experimental and Station Meters of any size made to order on the shortest notice.—Governors, Pressure Registers, Gas-cooking Stoves, and every description of Gas Apparatus.

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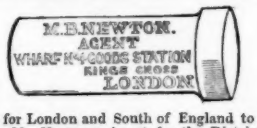

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N.B.—A few Retorts of each size, and a large stock of Bricks and Lumps, always on hand at the above Wharf.

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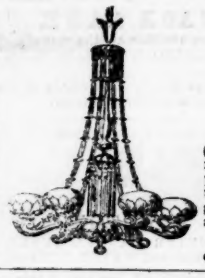

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(Made from "REGISTERED" DESIGNS), with GLASS BRANCHES, &c.; suitable for DRAWING-ROOMS and BALL-ROOMS. The more extensive use of GAS in private dwellings has induced Messrs. OSLER to direct their particular attention to the manufacture of this class of articles—which, with a view to their general adoption, are offered at very moderate prices. Purchasers can select from a great variety of patterns, to which additions are being constantly made.
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These RETORTS are generally used in the Gas-works of Preston, Accrington, Bury, Heywood, Middleton, Rochdale, Ratcliffe; the Mills of Messrs. Horrocks, Miller, and Co., Preston, &c. &c., and are unequalled in having afforded general satisfaction to those who have given these Retorts a trial.
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PRICES MODERATE.

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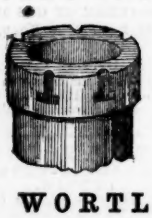

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To meet the yearly increasing demand of UPWARDS OF THIRTY SEASONS and to carry out the late improvements in the manufacture, the Premises have been re-erected and much enlarged, and Engineers may rely WITH CONFIDENCE on their orders being completed with a greater regard to despatch than by any other House.
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